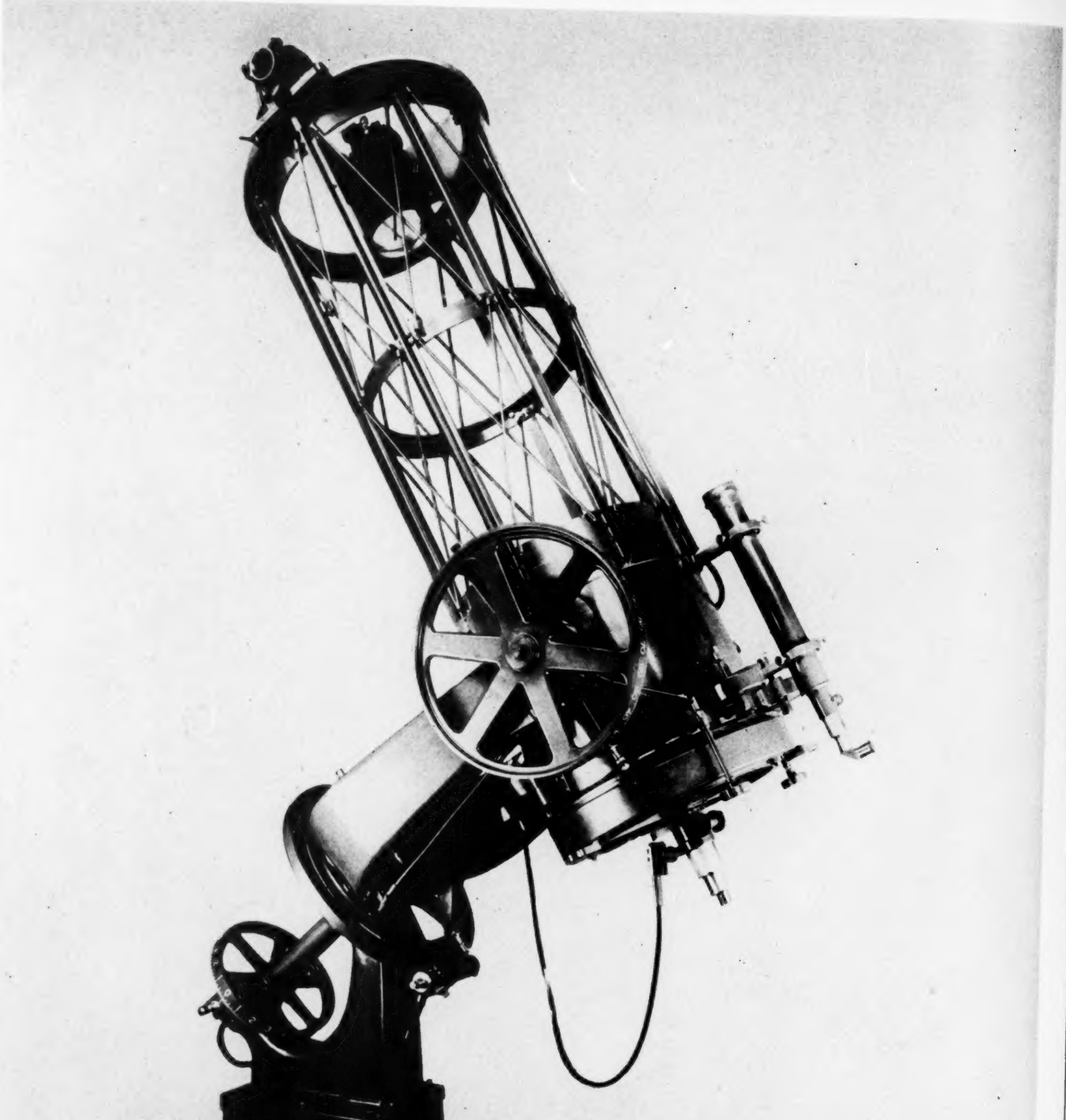
Sky and TELESCOPE

Nashville's new observatory

Vol. XIII, No. 3
JANUARY, 1954

In This Issue:



BRITISH ECLIPSE TOURS

The Royal Astronomical Society and the British Astronomical Association plan jointly to arrange transportation and accommodation for two parties to the total eclipse of June 30th, the most favorable event of its kind within easy reach of the United Kingdom until 1999.

The belt of totality passes north of the Shetland Islands, crosses the Norwegian coast at Bergen and enters Sweden some 80 miles north of Gothenburg, thence over the island of Oland and on across the Baltic Sea. In the Skagerrak, the duration of totality is 2½ minutes, the belt is 95 miles wide, and totality occurs 80 minutes before local noon. Weather prospects are poor on the west coast of Norway, but moderately good on both shores of the Skagerrak and on the Baltic coast.

Dr. A. Hunter, secretary of the RAS, writes that there will be one party open to about 160 people who can spare 10 days to see the eclipse, and an air party for those who have no more than 24 hours at their disposal. The main tour will leave London on Thursday, June 24th, going by Swedish Lloyd steamer to Gothenburg, Sweden, and thence by road to Lysekil, returning by the same route to reach London on July 3rd. Five nights will be spent in hotels at Lysekil, with coaches running northward to the central track on the 29th as well as the 30th, so that those who wish to set up observing apparatus may do so.

The air party will leave London in the early morning of June 30th and will fly along the eclipse track north of the Shetland Islands, arriving back in London the same evening.

American astronomers and amateurs likely to be overseas during the summer and wishing to participate in either of these tours are invited to communicate immediately with the Assistant Secretary, Royal Astronomical Society, Burlington House, London W.1, England.

RESOLVING POWER OF THE EYE

The dependence of the resolving power of the human eye upon the orientation of the test object has recently been studied in the laboratory by H. Leibowitz, of the University of Wisconsin. His tests with gratings show that resolving power averages seven per cent greater when the lines of the gratings are horizontal or vertical than when they are inclined. This difference increases with pupil diameter, but appears independent of the level of illumination. The results, published in the October *Journal* of the Optical Society of America, may have astronomical significance in connection with visual observations of close double stars or fine planetary detail.

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
HELEN S. FEDERER, *Managing Editor*
JOSEPH ASHBROOK, *Assistant Editor*

1954 ECLIPSE PHOTOGRAPH COMPETITION

For amateur observers in the United States and Canada, *Sky and Telescope* will conduct an eclipse photograph competition. The prizes will be $20, $10, and $5, respectively, for the three best photographs by different observers of the total solar eclipse on June 30, 1954. The pictures may be made from inside or outside the path of totality, with any combination of instruments and accessories.

An additional prize of $10 will be awarded for the best special-interest photograph of any subject related to the eclipse, such as the observing sites, equipment, groups of people, and so on.

Also, not more than five honorable mentions will be awarded.

Anyone except professional astronomers may enter the contest and may submit any number of photographs. Entries will be judged by the editorial staff of *Sky and Telescope* on the basis of combined pictorial and scientific excellence, with credit given for originality and results obtained in relation to size of equipment.

All prints submitted must be black and white, suitable for reproduction. These may be contact prints or enlargements, single photographs, pictures cut and mounted to form a sequence, series shots, series of motion picture frames, and so forth. Each picture must be accompanied by information on the equipment used, exposure data, special techniques, darkroom procedure, and other pertinent notes on the observing program.

Entries must reach the office of Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass., not later than Wednesday, July 21, 1954. It is suggested that from distant points air mail special delivery be used to meet this deadline, to avoid delay or damage in the mails. Contest entries must be clearly marked to distinguish them from other photographs and accounts of eclipse experiences that are submitted for possible publication.

The winning pictures will be published in our September issue. Other entries will be returned to the sender if adequate return postage is provided, but Sky Publishing Corporation cannot be responsible for the safe return of such entries.

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CONTENTS

COVER: The Arthur J. Dyer Observatory, of Vanderbilt University, situated in the Brentwood Hills 10 miles south of Nashville, Tenn. The 24-foot dome houses a 24-inch reflector that will be used with a Baker reflector-corrector as a wide-angle camera. Photograph by Ken Spain. (See page 72.)

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The principal articles in SKY AND TELESCOPE, beginning with Vol. XII, are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

The author here stands at the projector in the center of the planetarium chamber, which is formed by a 22-foot steel dome, the lower four feet of which may be raised flush with the ceiling when the room is used as a lecture hall. The Barnard Astronomical Society holds its meetings in this room. All photographs with this article are by Ken Spain.

The New Arthur J. Dyer Observatory

By Carl K. Seyfert, *Vanderbilt University*

EARLY in March of 1946, the writer received a telegram from Vanderbilt University in Nashville, Tenn., stating that they had a telescope mirror and were looking for an astronomer to go with it. Snow was still on the ground in Cleveland, Ohio, where I had been working at the Warner and Swasey Observatory for four years. Astronomers don't often have a chance to go south when the weather is dreary, and I welcomed the opportunity for a pleasant trip.

In Nashville, the grass was green, birds were singing, and roses were blooming. Added to nature's attractions, the opportunity offered by Vanderbilt appealed to me so much that I accepted, arriving in Nashville with my family in September.

On the university campus, there was a small observatory, named for Edward Emerson Barnard, housing a 6-inch Cooke refractor and a 4-inch meridian circle. During the war years Vanderbilt had been given a 24-inch telescope mirror by the Ferguson family of Cleveland, on the condition that ways and means be found to build a telescope around it and a modern observatory to house it. The finding of these "ways and means" provided me for the next six years with the most exciting, sometimes heartbreaking and certainly backbreaking days of my life. What spurred me on more than anything else was the warmhearted generosity of the people who helped us with our dream. Eighty firms and individuals, mainly in Nashville, co-operated in the new observatory project.

The campaign began with lectures on astronomy and the proposed observatory to various civic groups. There was already considerable interest in astronomy in Nashville since Barnard, the noted astronomer, had been born here.

After three years, such lecturing began to pay off. Following a talk at the Rotary Club, Arthur J. Dyer, founder of the Nashville Bridge Co., asked how to build a sundial for his home in Brentwood, a suburb of Nashville. I supplied him with the necessary information. This was probably the most expensive sundial ever built, since Mr. Dyer, for whom the observatory is named, and his bridge company became our largest contributors.

Mr. Dyer, a most energetic octogenarian, walked with me over most of the hills in and around Davidson County searching for the most suitable site. We found an ideal location consisting of a flat hilltop 1,100 feet high and nine acres in extent, in the Brentwood Hills 10 miles south of Nashville. Howard Gardner persuaded his brother, Carl, owner of the property, who lived in Morristown, N. J., to donate the land for the observatory site.

A road was the next problem, since the hilltop was more than a mile from the highway. The Oman Construction Co. agreed to use its machines and do the grading as a gift in memory of John Oman, Jr. Metal culverts were donated by another concern, dynamite by another, equipment and labor for blasting by a fourth, a black-top surface by still another, and finally the gravel topping by a sixth organization. The Nashville Electric Service Co. installed 2,000 feet of power line to the top of the hill as a gift.

In Chattanooga, Tenn., there lived a friend of mine, the late Clarence T. Jones, an amateur astronomer of some note. He was an architect and had built and donated to the university there a very fine small observatory. He and his son, Bruce Jones, agreed to prepare the plans and engineering drawings for the observatory at a very nominal sum.

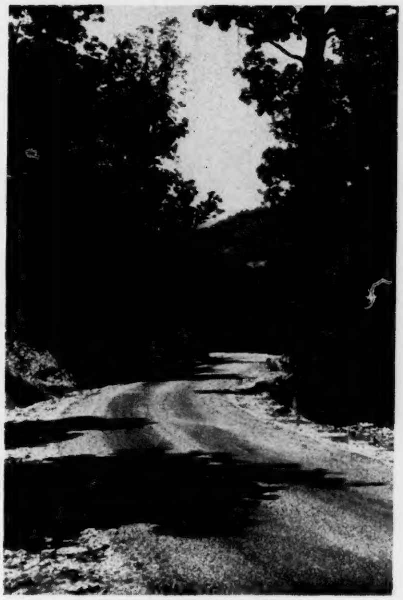
By this time it had become apparent that the cost of construction of the observatory itself would be prohibitive if the building were to be built in the usual fashion, so Mr. Dyer and I began calling on some of our friends. We were successful in obtaining all the sand and gravel, the bricks, the reinforcing steel, the electrical materials and their installation, all the hardware, form lumber, tile pipe, steel sash, glass and glazing. The mixing and delivery of concrete, four carloads of slag from Birmingham, Ala., for the concrete blocks, the construction of the blocks themselves, the trucking of the sand and gravel, and a large septic tank were all

procured without cost. Jack Lee, of the Rock City Construction Co., agreed to do the general contracting for the project without any charge for overhead, but he insisted on a profit to his company of one dollar! Mr. Dyer and the Nashville Bridge Co. contributed the 24-foot revolving dome of 1/4-inch steel plate for the telescope and the 22-foot steel planetarium dome in the auditorium.

The co-operation of the people of Nashville was heartwarming. Shortly after a radio talk on my favorite subject, a telephone call came from a man I had never met. "Do you have your plumbing fixtures?" he wanted to know. I said we didn't. He told me to come down the next day and he would give me all the necessary fixtures. With these in hand, figuratively speaking, I next went to a plumbing contractor, who agreed to install all the fixtures without charge. The whole project snowballed in this fashion. My catch phrase to prospective contributors became, "I know you won't want to be left out of this project." My wife warned me that someday someone might say, "Oh, yes I do." But no one ever did.

One unusual gift was that of a 50-foot hole in the ground presented by a well digger as the start of a 200-foot well. Unfortunately neither water nor oil was struck, and rain water is now caught on the roof area of the observatory, filtered, and stored in a 28,000-gallon cistern.

The mounting of the telescope was constructed by the J. W. Fecker Co., of Pittsburgh. The instrument itself consists of a combination 24-inch reflector and wide-angle Schmidt-type camera. In this latter form, the telescope will be of a new design invented by Dr. James G.



The road leading from the main highway to the Arthur J. Dyer Observatory.

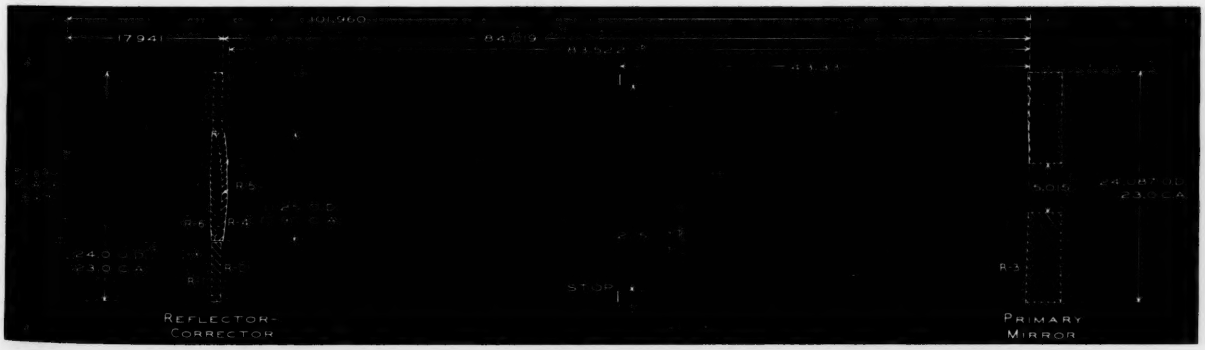
Baker, research associate of the Harvard Observatory.

The Baker reflector-corrector, as it is called, consists of an annular correcting plate with a low-power lens centered in the annulus and placed at about the position normally occupied by the Cassegrain secondary in a conventional reflector. Thus the starlight, after passing through the annular correcting plate, is reflected from the mirror back through the central lens to a focus at the center of the uppermost end of the tube. The photographic plate is placed at this point. The reflector-corrector lens transforms the narrow-angle reflecting telescope into a fast wide-angle, flat-field instrument.

Since this new telescope uses a parabolic primary, rather than a spherical mirror as in the case of the Schmidt telescope, it is possible to convert to a conventional reflector by replacing the reflector-corrector with one of the usual secondaries. Thus the telescope will have three possible focal lengths: seven feet (reflector-corrector), nine feet (Newtonian), and 33 feet (Cassegrainian). This convertible feature and the advantages of wide field, flat focal plane, and short tube length, make the Baker reflector-corrector telescope a unique and extremely versatile instrument.

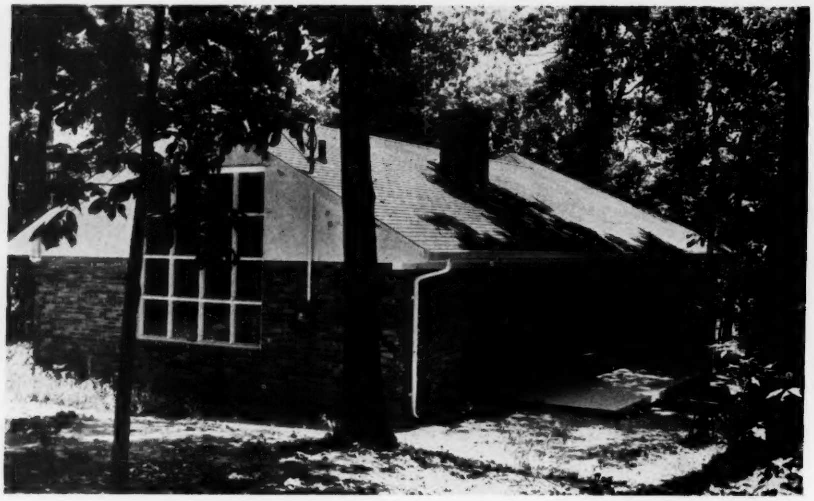
During the dark of the moon, the telescope will be used with the reflector-corrector to photograph the Milky Way in a program designed to improve our knowledge of the structure of the galaxy. During the bright of the moon, when the fast-camera feature is least useful, the reflector-corrector will be removed, a Cassegrain secondary put in its place, and a photoelectric cell attached at the lower end of the tube. With this arrangement, studies will be made of the precise light variation of eclipsing stars for the determination of masses, diameters, and densities of these double systems. This latter work will extend an investigation conducted by the writer earlier with a 12-inch telescope built by John and Ward DeWitt, of Nashville.

Vanderbilt University furnished the funds necessary for the mounting of the telescope, and the Research Corporation of New York made a grant of $10,000 available for the optics. The Corning Glass Works donated a 24-inch blank of optical glass for an objective prism. Requests for estimates on the optics were sent to various concerns. Perkin-Elmer Corp., Norwalk, Conn., submitted an



REFLECTOR-CORRECTOR ARRANGEMENT OF THE DYER OBSERVATORY TELESCOPE

In this scale drawing all dimensions are given in inches, and the abbreviations O. D. and C. A. mean outside diameter and clear aperture, respectively. The primary mirror is a paraboloid, with a vertex radius of curvature (R-3) 214.50 inches and focal length 107.25 inches. However, the effective focal length of the telescope in this combination is 81.801 inches, with optimum correction at 4341 angstroms. The diagonal of the plate is six degrees. The focal plane can be moved an inch either way for focusing. The stop is used for photographic purposes only. The surfaces of the corrector have the following radii (in inches): R-1, infinite; R-2, aspheric (figured in parallel light to give a flat cutoff); R-4, 39.00 ±.030; R-5, 20.71 ±.030; R-6, 228.3 ±.30. Surfaces R-1 and R-2 are on 523586 glass; R-4-5, on 617366 glass; and R-5-6, on 517645 glass. Their thicknesses are R-1-2, 0.90 ±.10; R-4-5, 0.49 ±.02 (at vertex); and R-5-6, 1.062 (at vertex). When the telescope is used as a Newtonian or Cassegrainian, the corrector plate is swung out of the way and replaced by a secondary mirror. The first article in "Amateur Telescope Making — Book 3," edited by Albert G. Ingalls, is by Dr. James G. Baker, who describes there the advantages of this reflector-corrector design.



The director's residence on the grounds of the Dyer Observatory.

estimate of $15,000. When informed that our funds were not sufficient, Richard Perkin, the head of the company, sent Vanderbilt University a check for $5,000, which added to the $10,000 grant from the Research Corporation, enabled us to have Perkin-Elmer construct the optics.

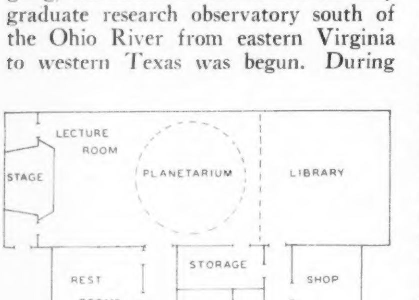
Of course, it takes more than bricks and plumbing to build an observatory. The necessary funds to purchase the materials that could not be obtained as gifts and to pay for the actual labor of construction were contributed jointly by Mr. Dyer and Vanderbilt University. Finally, a grant of $12,000 from the National Science Foundation assured the success of the whole project, the total valuation of which is in excess of a quarter of a million dollars.

At the end of March, 1952, after six years of planning, hoping, and struggling, the actual construction of the only graduate research observatory south of the Ohio River from eastern Virginia to western Texas was begun. During most of the construction my family and I lived in our house trailer on the site. As the observatory neared completion and the cold weather approached we scarcely waited for the building to be roofed over before moving into it, while construction was begun on the residence. In the meantime the historic Barnard Observatory had been torn down to make way for a new university dining hall, and the bricks were used in the construction of the residence.

The observatory houses, in addition to three offices, a visiting astronomer's apartment, a shop, an air-conditioned darkroom adjoining the observing dome, a 70- by 24-foot auditorium which is a combination lecture hall, library, and planetarium. The planetarium consists of a 22-foot steel hemisphere, the lowest four feet of which can be raised or lowered; when the room is used as an auditorium the dome is raised to ceiling height. The planetarium instrument was constructed in the shops of the Vanderbilt school of engineering. The research library, which can be closed off from the rest of the auditorium by an accordion door, contains a fine collection of astronomical publications. The publications of the Arthur J. Dyer Observatory have already begun. Reprints Nos. 1 and 2 have been distributed.

The new observatory will be open to the public at regular intervals for popular lectures, planetarium shows, and observations through the telescope. It is hoped that many astronomers will avail themselves of the visiting astronomer's apartment.

The dedication of the observatory and its telescope is scheduled for December 27, 1953. Representatives of the 80 firms and foundations which donated more than $200,000 in services, materials, and money, have been invited to be present when Mr. Dyer, representing the original contributors, presents the observatory to Vanderbilt University. The three days following the dedication are being devoted to the annual winter meeting of the American Astronomical Society.



The layout of the lower floor of the observatory. The observing chamber and darkroom are on the second floor.

LETTERS

Sir:

I have been asked by several professional and amateur astronomers to comment on the star list published by Comdr. Edwin A. Beito, of the U. S. Naval Academy, in the March, 1953, number of **Navigation,** which is referred to by Dr. Dorrit Hoffleit in the August News Notes of **Sky and Telescope.** This list contains proper names and the Bayer designations of the 57 selected stars of the **Nautical Almanac** and **Air Almanac.** Several changes in spelling have been made, such as Betelgeuse for Betelgeux, which help to make the list more nearly correct and more acceptable. Other names, however, have been gratuitously coined, and still others have been wrongly assigned to the stars.

There is a great and, in most cases, a very ancient tradition behind star names, which can be appreciated by anyone who will give a little thought and study to the subject. The amateur takes a certain amount of pride in being able to call the stars by their proper names, and the professional astronomer writes his learned and technical papers on Pleione, Arcturus, Algol, and Procyon. Several star names, such as Acrux and Miaplacidus, were fabricated over a century ago, and may well remain on our lists. But I sincerely and strenuously object to anyone taking upon himself the authority to begin a new era of star naming. Let us use the names that have come down to us through the centuries and be content with them.

Without further discussion, I recommend the following:

1. The following names should be deleted because they are simply meaningless fabrications: **Ankaa** for α Phoenicis, **Avior** for ε Carinae, **Gacrux** for γ Crucis, **Menkent** for θ Centauri, and **Atria** for α Trianguli Australis.
2. **Suhail** for λ Velorum should be deleted because it is the Arabic name of Canopus, and, without a modifying adjective, is not the name of any other star.
3. **Peacock** for α Pavonis should be deleted because it is the translation into English of the name of a modern constellation, not the name of a star.
4. **Al Na'ir** for α Gruis should be deleted because alone it is not the name of any specific star. In Arabic it simply means "the bright one."
5. **Hadari** (not **Hadar**) for β Centauri should be retained because it is one of the most ancient Arabic star names. It is pronounced **Hah-dah-ree,** with the accent on the second syllable. I have submitted an article on this star name to **Sky and Telescope,** in which I show that the name is an imperative verb and not a noun.

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Buffalo 2, N. Y.

The scene during the transit on the campus of the University of Toronto, where members of the Royal Astronomical Society of Canada set up their instruments for the public.

MERCURY TRANSIT ROUNDUP

MORE THAN 50 reports of the passage of Mercury across the sun on November 14, 1953, have already been received by *Sky and Telescope*. These list observations by some 150 people. Favorable weather prevailed over most of North America, so that this rare event was widely observed.

The accounts describe the transit as viewed with optical means ranging from a 20-inch telescope to binoculars, by persons from California to Massachusetts and from Ontario to Argentina. So extensive are the reports that it is not possible to publish individual letters about the transit; this article will instead summarize some of them.

On the whole, satisfactory timing was carried out by many observers, and about 150 observations of contact times are already in hand; an analysis of these will be published in a subsequent issue.

Good visibility was enjoyed by watchers from Ontario to Virginia, Georgia, and Trinidad. A small region centered on New York and Philadelphia was overcast, and at Montreal the sun did not shine all day. In New England, the phenomenon was partly hidden by broken cloud. From Ohio westward, reports generally indicate clear skies, but often, as at Chicago, strong winds impaired the steadiness of the telescopic images.

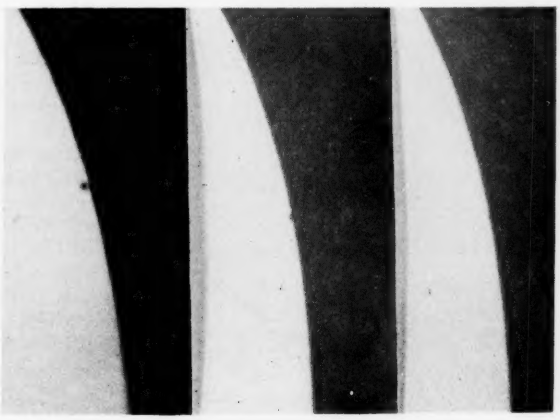
The diversity of instruments used to show the transit is matched by the variety of devices for reducing the sun's glare. These arrangements are well worth consideration, for their usefulness is not limited to transits alone, but is generally applicable to solar observing. Especially, they may offer suggestions to those who plan to watch the partial phases of the solar eclipse on June 30th.

Many observers employed such standard methods as dark filters, Herschel wedges, and especially projection of the sun's image through an eyepiece upon a screen. Several persons with reflectors reversed their prisms, so that only a weak external reflection took place, instead of total internal reflection, thereby allowing the use of lighter filters. At Wauwatosa, Wis., E. B. Heckenkamp placed a Herschel wedge in the usual position of the diagonal of his 8-inch reflector. C. E. Ott, Norwalk, Wis., and Dr. W. A. Calder, at Bradley Observatory, Decatur, Ga., worked with unsilvered mirrors in their reflecting telescopes.

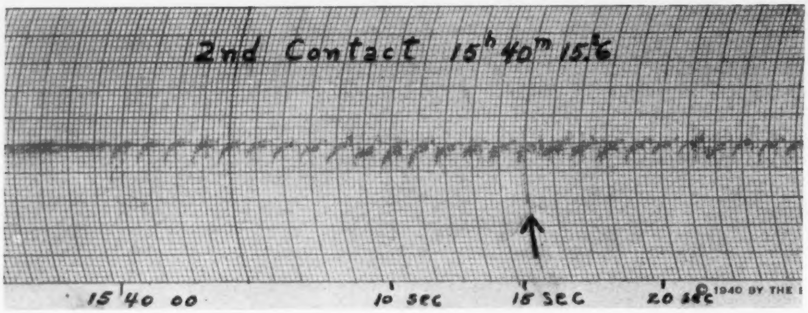
Another procedure, followed by T. J. Ogburn, III, Richmond, Va., with a 4-inch refractor, utilized a penta-prism ahead of the eyepiece. Most of the light entering the first surface of this prism is harmlessly transmitted out of the optical system; the remaining light is so further depleted by reflection from the second surface, which is coated with black enamel, that it can be comfortably viewed without a shade glass. This arrangement is equivalent to three Herschel wedges in tandem.

Equally varied were the ways in which observers made use of radio time signals in determining contact times. Their methods will also prove of value in timing occultations and contacts at solar eclipses. The simplest was to place a short-wave receiver tuned to the WWV signals alongside the telescope, and to

Beaufort S. Ragland, of Richmond, Va., timed the transit contacts by photographing a railroad watch for the hour and minute, and a stop watch for the seconds. These pictures show the time of second contact, and that the stop watch kept good time with the WWV signals over an interval including the contact.



David L. Clow, of the Denver Astronomical Society, photographed these portions of the 6-foot image of the sun projected by the 20-inch refractor of the Chamberlin Observatory. At the right, Mercury makes a barely perceptible dent in the sun's limb, just after first contact. In the center frame, it is easily seen, and in the third is well on the disk.



This time record was obtained by J. M. Spooner, Gas City, Ind., using CHU signals. Each pulse marks a second, with the end of every minute shown by the absence of signals, resulting in the smooth appearance of the tracing at the left.

count the seconds. This requires both practice and much care, for the minute is easily mistaken, and indistinctness of the signals at the crucial time may cause loss of the observation.

A refinement of this basic technique was employed by Luc Secretan at Washington, D. C., who made a tape recording of the WWV signals, with spoken signals at contact times. By playing back the tape several times he could be sure that no misinterpretation of his timing had occurred. He also recorded his oral comments on the phenomenon, and could reconstruct times to which they referred. This is a very valuable technique which should have widespread application in astronomical observations.

The same procedure was followed by Dr. Calder, with the difference that a buzzer was sounded at the moment of contact. On playing back this recording, he found that the instrumental error did not exceed 0.2 second; the uncertainty in judging visually the time of contact is always greater than this. Related to this procedure is J. M. Spooner's use, at Gas City, Ind., of a Brush recorder, on whose moving paper strip radio time signals were registered, and into which he keyed the instants of the contacts.

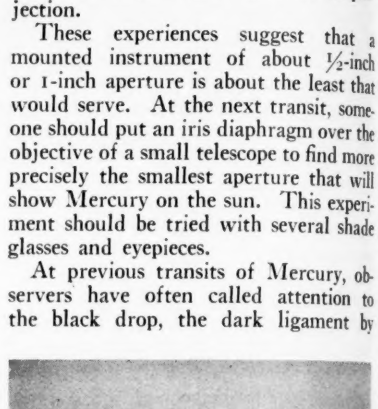
Photographs of the transit were made by Spooner, Dr. Calder, Secretan, and many others. Evidently, satisfactory pictures can be obtained with rather small telescopes, as was demonstrated by P. R. Lichtman, Washington, D. C., who used a 3-inch refractor stopped down to 1½ inches. Working with a projected solar image 15 inches in diameter, he took 1/100-second exposures showing images of Mercury about 1/16 inch in diameter.

A graphical record of Mercury's track across the sun was obtained without recourse to photography by K. Walko in Maple Heights, Ohio. He fitted a rigidly attached projection screen to his 8-inch reflector, and placed a reticle in the focal plane. Thus he could readily bring the sun's image to the same position on the screen, and then mark Mercury's location with a pencil.

One question which must have occurred to many in connection with the transit is: What is the smallest telescope that can show Mercury on the sun? While the delicate operation of timing the contacts is best carried out with at least a 3-inch refractor or a 5-inch reflector bearing fairly high magnification, much smaller instruments can give a view of the planet during transit. This problem was considered by Dr. William S. Challman, who observed under favorable conditions at Mt. Vernon, Ind. He found that Mercury could not be distinguished with either the naked eye or hand-held 7 x 35 binoculars, used with suitable dark filters. However, the planet was clearly seen in tripod-mounted aircraft-spotting binoculars of 1¾-inch aperture and 10 power. Paul W. Stevens, at Rochester, N. Y., found a 2-inch, 8x refractor very successful for demonstrating the transit to the public. At Toronto, according to E. V. Greenwood, a 2-inch, 40x glass gave fine views to many spectators. What is said here refers to direct vision and not to projection.

These experiences suggest that a mounted instrument of about ½-inch or 1-inch aperture is about the least that would serve. At the next transit, someone should put an iris diaphragm over the objective of a small telescope to find more precisely the smallest aperture that will show Mercury on the sun. This experiment should be tried with several shade glasses and eyepieces.

At previous transits of Mercury, observers have often called attention to the black drop, the dark ligament by



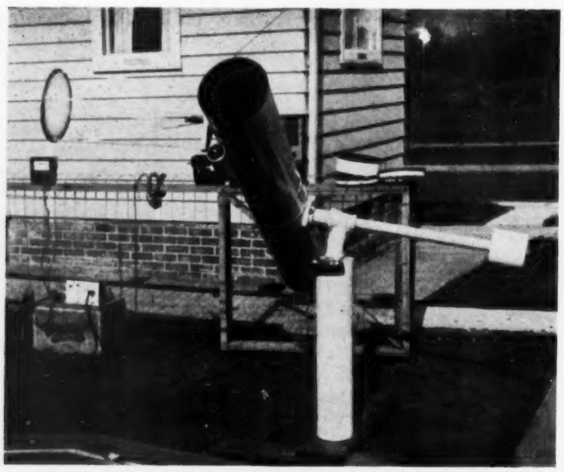
Mercury just before third contact, near the north point of the sun's limb, photographed by Mr. Spooner.

which Mercury appears to hang from the sun's limb near the beginning or end of the transit. Anyone can produce the same effect by holding two fingertips together close to the eye in front of a bright background and slowly separating them.

Only some of the observers of the 1953 transit seem to have seen the black drop effect. At Baton Rouge, La., Dr. D. V. Guthrie and three others observed the transit by projection with the 11½-inch refractor of the Louisiana State University. They saw no black drop either at ingress, when the seeing was excellent, or at egress, when the seeing was poor.

An interesting black-drop observation was recorded at the Laws Observatory, Columbia, Mo. After the black drop had broken at second contact, it momentarily re-formed in a brief interval of good seeing. At the Adler Planetarium in Chicago, several observers with 3½-inch reflectors had the impression that the black drop lasted 20 seconds longer with dense filters than with light; this point deserves further test at coming transits. It is suggested that

(Continued on page 84)



At Maple Heights, Ohio, Kenneth L. Walko attached the screen shown at the left to his homemade 8-inch reflector. A short-wave receiver can be seen on the box in the background.

NEWS NOTES

By Dorrit Hoffleit

STAR FACTORY

For the past six years astronomers and engineers at the Watson Scientific Computing Laboratory, operated jointly by Columbia University and the International Business Machines Corporation, under the direction of Dr. Wallace J. Eckert, have been developing a machine that is nicknamed "star factory." It is designed to measure the positions of star images on photographic plates. Work that would take a highly trained human observer a week, the machine can do in one day, and with four times the accuracy.

The "star factory" will handle plates as large as 17 inches square having from 300 to 450 measurable star images. The machine is fed IBM cards telling the positions known from previous star catalogues. Then it goes to work scanning the immediate vicinity of the predicted position for a star; when its photoelectric eye has found and centered on the position (to within tenths of a micron), it automatically punches the new coordinates on the cards. These are then ready for whatever machine computations, such as the determination of proper motions, the astronomers wish to carry out.

BULGES ON THE SUN'S LIMB

A recent number of the AAVSO Solar Division *Bulletin* has two articles on distortions of the solar limb. Although gifted observers like Secchi reported limb distortions in the 19th century, modern observations have often been received skeptically, mainly because the instruments used were too small and the seeing conditions unfavorable for revealing real effects as small as one second of arc. The first of the AAVSO papers is a preliminary note by Harry Bondy on distortions observed on five dates in 1951. One of them was seen by two, another by four observers widely separated geographically. Although the significance of these distortions is not understood, they did occur at times and in areas of other solar activity. Their dimensions are not given, but the author states that the over-all heights were too small to be recorded photographically.

The other paper, by Dr. M. Waldmeier, of Zurich, describes a remarkable distortion on March 6, 1953. It appears to have been of a different type, for at this time no other solar activity such as flares or sunspots was evident, and it was larger and of much shorter duration than those previously recorded. The object on the sun's limb, unique in Dr. Waldmeier's 20 years' observing experience, was discovered while he was adjusting his coelostat half an hour after sunrise on a day when observing conditions were exceptionally fine. Even while he was tracing the outline of the sun, the size of the "nose" diminished. He estimated that his observations lasted some 40 seconds; they began at or after maximum, and hence the entire phenomenon could have lasted a few minutes. The height of the nose or wart was about 5,000 kilometers. It could not have been caused by any terrestrial atmospheric effects. In brightness and color it was indistinguishable from the adjoining portions of the limb.

No purely solar process seems to account for the occurrence, writes Dr. Waldmeier. The region of the distortion was checked with the coronagraph at Arosa, where the observations were made, but there were no unusual corona phenomena and no prominence activity. He suggests cautiously that it might have been caused by the fall of meteoritic material into the sun, or perhaps the close passage of a cosmic body.

NEW EXTRAGALACTIC DISTANCE INDICATORS

In the British magazine, *Observatory*, C. S. Gum and G. de Vaucouleurs, of Australia, report on the possible use of certain H-II regions (emission nebulae of luminous hydrogen gas) for the determination of the distances of external galaxies. Some of these regions have the shape of rings or partial rings, and examples in our own galaxy are found in Orion, Scorpius, and the Vela-Puppis area. In six galaxies, including the Milky Way, they found that the largest of these ringlike structures have very nearly the same linear diameter, averaging 85 parsecs in a range of 71 to 92 parsecs.

This indicates that we can assume a constant linear diameter for the largest such object in any external galaxy and from its apparent diameter (in seconds of arc) compute the distance to the galaxy. If this discovery is substantiated by more abundant material, it will aid considerably in measuring the distances of other star systems.

IN THE CURRENT JOURNALS

MT. WRANGELL EXPEDITION, by Arthur Beiser, **Physics Today,** October, 1953. "The summit of a dormant volcano nearly three miles high and located in the wilds of central Alaska—this is the unlikely site of a cosmic-ray laboratory that was put into operation during the past summer."

T TAURI AND HIND'S NEBULA, by George H. Herbig, **Leaflet** No. 293, Astronomical Society of the Pacific, September, 1953. "...the inner and outer nebulosities at T Tauri are significantly different in physical conditions, for reasons we do not now understand.... We are probably witnessing no more than the play of light and shadow on a relatively fixed curtain of dust clouds."

THE AGE OF THE UNIVERSE, D. ter Haar, **Scientific Monthly,** October, 1953. "The data...afford, as far as the present author can see, one of the strongest arguments against the hypothesis of continuous creation."

RADIO WAVES FROM INTERSTELLAR HYDROGEN, by Harold I. Ewen, **Scientific American,** December, 1953. "Today listening posts all over the world are tuning in on this high-pitched monotone at 1420 megacycles, and from it they are obtaining a new picture of the universe."

HAYDEN PLANETARIUM

Joseph M. Chamberlain has recently been appointed general manager and chief astronomer at the Hayden Planetarium of the American Museum of Natural History in New York. On the staff since 1952, he had formerly taught astronomy and meteorology at the Merchant Marine Academy at Kings Point, N. Y.

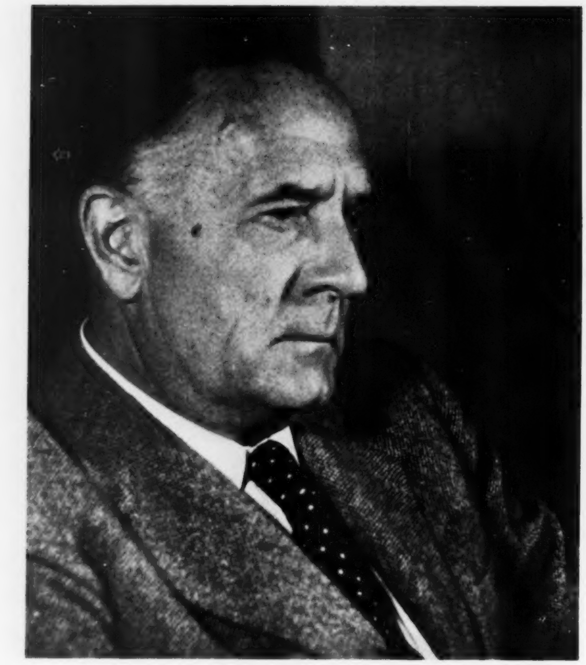
A record year of operation is reported by the planetarium for July, 1952, through June, 1953, when there were 509,378 paid admissions. In August and December, 1952, and April, 1953, attendance exceeded 50,000 each month. Not since 1936-37, first full year of the planetarium's operation, had the annual figure been so high nor had the 50,000 mark been reached in monthly attendance. These figures do not include people attending the courses in astronomy and navigation, nor the free junior high school program conducted in co-operation with the city's board of education.

BUTLER UNIVERSITY OBSERVATORY AND PLANETARIUM

The largest telescope in Indiana will be made for Butler University by the J. W. Fecker Co., of Pittsburgh. It will be a 38-inch Cassegrainian reflector, fork-mounted with an open tube. There will be a 5-inch guide telescope and a 3-inch finder. The instrument will cost $48,500 and will be completed in about 10 months.

Meanwhile, on a high knoll 200 yards north of Butler's main building, Jordan Hall, work is being started on the observatory building, a gift of J. I. Holcomb. The telescope will be housed in a dome 24 feet in diameter, its top reaching a height of 55 feet. The dome will be made of a material new for astronomical purposes, "cocoon," a plastic developed during the past war.

The west wing will have an air-conditioned planetarium chamber seating 80 persons. In the east wing there will be a class and lecture room 24 feet square. The central lobby calls for elaborate decorative designs based on the zodiac.



Edwin Hubble
Observational Cosmologist

By N. U. Mayall, *Lick Observatory*
University of California

Edwin Hubble (1889-1953). Photograph by Jay Barrie.

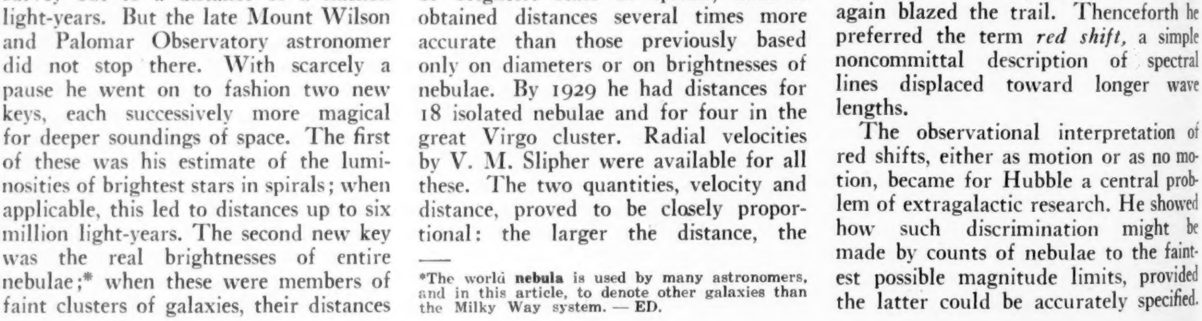
"THE FIRST extragalactic Cepheid was definitely recognized toward the end of 1923 in M31." These words, from Edwin Hubble's book, *The Realm of the Nebulae,* refer to the master key that opened the way to measurement of the farthest reaches of extragalactic space. With the Cepheid criterion, he made the first reliable survey out to a distance of a million light-years. But the late Mount Wilson and Palomar Observatory astronomer did not stop there. With scarcely a pause he went on to fashion two new keys, each successively more magical for deeper soundings of space. The first of these was his estimate of the luminosities of brightest stars in spirals; when applicable, this led to distances up to six million light-years. The second new key was the real brightnesses of entire nebulae;* when these were members of faint clusters of galaxies, their distances could be measured up to 250 million light-years. The limit was reached, on 100-inch reflector photographs, with the faintest recognizable nebulae. If some of these were intrinsically bright giants, they marked the boundary of the observable universe at a distance of 500 million light-years.

Directly as a consequence of his use of brightest stars in spirals, Hubble obtained distances several times more accurate than those previously based only on diameters or on brightnesses of nebulae. By 1929 he had distances for 18 isolated nebulae and for four in the great Virgo cluster. Radial velocities by V. M. Slipher were available for all these. The two quantities, velocity and distance, proved to be closely proportional: the larger the distance, the greater the velocity of recession. Such a relationship had to some extent been anticipated by Lundmark and Wirtz from fewer and less precise data, and by de Sitter's mathematical work using relativity theory. But Hubble's new approach clarified an obscure situation and laid a firm foundation for a spectacular advance involving fainter and more distant nebulae.

While Hubble measured total brightnesses of galaxies in clusters to obtain increasingly greater distances, his colleague Milton Humason photographed their spectra for the measurement of radial velocities. The results were of unprecedented interest: a straight-line relationship between distances out to 250 million light-years and velocities of recession up to 26,000 miles per second. These data were forthwith exploited by theorists into the concept of the expanding universe. But when apparent velocities for entire stellar systems reached nearly one seventh the velocity of light, there seemed to be good reason to ask if the spectrum measurements really represented motion, and here Hubble again blazed the trail. Thenceforth he preferred the term *red shift,* a simple noncommittal description of spectral lines displaced toward longer wave lengths.

The observational interpretation of red shifts, either as motion or as no motion, became for Hubble a central problem of extragalactic research. He showed how such discrimination might be made by counts of nebulae to the faintest possible magnitude limits, provided the latter could be accurately specified.

*The world **nebula** is used by many astronomers, and in this article, to denote other galaxies than the Milky Way system. — ED.



These notes in Hubble's observing book record his recognition of the first Cepheid variable in the Andromeda nebula, M31, on plate H335H (right), which he took on October 5, 1923, with the 100-inch Mount Wilson reflector.

His formulation of the problem indicated that the crucial data lay at the dim threshold of long exposures taken with the 100-inch reflector. From a bold use of this instrument to the limits of its power, he concluded that red shifts *may* represent a new phenomenon, rather than velocities of recession. He was well aware, however, that a more powerful telescope was necessary for a definitive solution of the problem, and his researches on nebulae furnished some of the strongest arguments for the construction of the 200-inch reflector. He actively supported the project from its beginning, and it is fitting that he made the first photographic observations of nebulae with the Hale telescope.

But Hubble did far more than set up a distance scale to follow the mysterious red shifts out to an enormously extended astronomical horizon. He undertook detailed, comprehensive studies of the contents and properties of the vast volume explorable with the largest telescope. His published writings, which require five pages merely to list, include work on, reference to, or consideration of nearly every aspect of extragalactic research. He examined nebulae as individuals, and produced a classification system generally used as the standard. He made extensive counts of nebulae on plates taken with the large Mount Wilson reflectors, and obtained for the first time quantitative information on the large-scale occurrence of obscuring matter in the galaxy, on the numbers of nebulae to successively fainter magnitude limits, on the tendency of nebulae to cluster, and on the average density of matter in extragalactic space. He studied in the nearer systems almost every kind of intrinsically bright object known in the galaxy: novae, globular star clusters, gaseous nebulae, supergiant blue stars, red long-period variables, and Cepheids.

By these multifarious researches, Hubble revolutionized our knowledge of the structure of the universe and became an outstanding leader in the observational approach to cosmology — the study of the universe in its broadest aspects. Although he regarded himself primarily as an observer assembling and analyzing empirical data, there is abundant evidence in his writings that, from the very beginning of his astronomical career, he took the widest possible view of the relationship of his investigations to the general field of cosmology. Even in his thesis (1920), written when the nature of nebulae as extragalactic systems had not yet been established, he conjectured: "Suppose them to be extrasidereal and perhaps we see clusters of galaxies; suppose them within our system, their nature becomes a mystery." Then, in his first detailed paper (1925) on an extragalactic system (NGC 6822), whose distance he obtained from

The first 200-inch photograph, taken January 26, 1949, when the seeing was poor, of the variable nebula NGC 2261, which involves the star R Monocerotis.

the Cepheid criterion, he wrote: "The principle of the uniformity of nature [implied by the Cepheid period-luminosity law] thus seems to rule undisturbed in this remote region of space. This principle is the fundamental assumption in all extrapolations beyond the limits of known and observable data, and speculations which follow its guide are legitimate until they become self-contradictory."

As his rapid exploration proceeded, his point of view became still more general to keep pace with the enlarging field of operation. Thus in his Halley lecture (1934) and later in his book (1936) he considered a great sphere of 500 million light-years radius as the "observable region." If this volume, he repeatedly emphasized, is a "fair sample," then by the principle of the uniformity of nature, we may infer something of the properties of the universe as a whole. While this philosophy of research may have had a somewhat mystical quality, it nevertheless represented a definite break with the past. Before Hubble, abstract metaphysical reasonings were the rule; after him, cosmology was brought down to earth with a wealth of observational data, much of which he had collected and systematized.

Hubble regarded his work as a "preliminary reconnaissance" of space. In a sense it was an architect's initial set of plans, subject to alterations, additions, and an eventual filling-in of more details. It is remarkable, however, the degree to which he anticipated and provided for future developments. One of the most important of these is, of course, the extragalactic distance scale, which currently is undergoing a major re-examination with the probability that all of Hubble's distances may be doubled. It would be wrong, however, to assume that his distances were "in error." He made plain from the beginning that his unit of distance was that of the Magellanic Clouds, in which the Cepheid criterion was discovered by Henrietta Leavitt, of the Harvard Observatory. In fact, one of the reasons for doubling extragalactic distances traces back to Hubble's work (1932) on the globular clusters he discovered in M31. He found their luminosities fainter by an average factor of nearly 4, when compared with globular clusters in our galaxy. The discrepancy persisted for 20 years, until the 200-inch reflector, used expertly by W. Baade, gave independent evidence that the Andromeda nebula probably should be assigned a two-times greater distance.

An important problem in extragalactic research that barely resisted attack by Hubble was the resolution of elliptical nebulae. There are a number of references in his papers, generally footnotes, to the starlike objects around the periphery of the bright elliptical nebula, M87, in the Virgo cluster, but he never regarded these objects as in-

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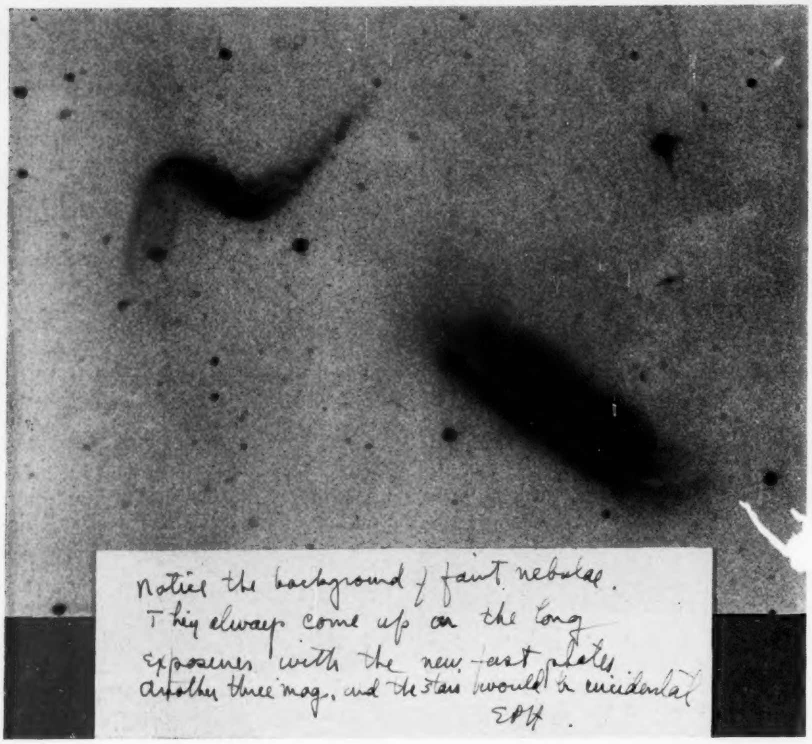
Edwin Hubble — 1889-1953

BORN on November 20, 1889, in Marshfield, Mo., Edwin Hubble took a B.S. degree at the University of Chicago in 1910, where he became interested in astronomy. He studied law as a Rhodes scholar for two years, and practiced in Louisville, Ky., after his admission to the bar. But in 1914 his deep interest in astronomy caused him to return to the University of Chicago for graduate study, and he received his Ph.D. degree in 1917. Enlisting in the U. S. Army's first Officer Training Corps, Dr. Hubble completed his service in World War I as a major. Following this he joined the staff of the Mount Wilson Observatory, where he remained except for three years from 1942 to 1945 spent at the Aberdeen Proving Ground in ballistics work. He received the Medal of Merit in 1946 for outstanding contributions to the war effort.

Dr. Hubble's scientific work is described in the accompanying article by Dr. N. U. Mayall. His astronomical accomplishments won world-wide recognition — he received five honorary degrees from colleges and universities here and abroad, and was awarded the Barnard, Bruce, and Franklin medals, and the Gold Medal of the Royal Astronomical Society, among others.

His civic activities included serving as a trustee of the Huntington Library and Art Gallery, and as a member and past chairman of the Los Angeles Committee on Foreign Relations. Dr. Hubble's death from a cerebral thrombosis occurred on September 28, 1953.



On the back of this negative print of a 100-inch photograph, Dr. Hubble wrote the comment reproduced here. The picture shows NGC 3187 (left) and NGC 3190. The latter was his test case for deciding whether spiral arms are trailing or not; note the faint outer arms on this long exposure.

dicative of the resolution of the nebula into stars. In the case of M32, the elliptical companion near M31, he has described it as "smooth and featureless, without the slightest suggestion of resolution." The closest he came to success was with NGC 205, another elliptical companion of M31. For this system he stated in his book, "Very faint stars are more numerous than would be expected for foreground stars alone, and some of them may be associated with the nebula."

Only these brief notes are in the printed record, as befits a cautious observer well acquainted with the limitations of his data. But once in conversation he drew out his best 100-inch plate of NGC 205, taken in 1921 on the slow Seed 30 emulsion, and remarked that his judgment as to possible resolution depended on what he "had for breakfast"!

In a later triumph of telescopic technique, Baade resolved with the 100-inch all the members of the M31 group, in connection with his significant work on the recognition of two distinct types of stellar populations. The principal material consisted of long exposures on fast, red-sensitive plates, taken during the war years when sky glare from city lights was at a minimum. The resolution of NGC 205 proved so easy in red light, however, that Baade also tried a modern, fast, blue-sensitive emulsion. His published description (1944) of this photograph parallels Hubble's impression. "The plate reveals incipient resolution of NGC 205 quite unmistakably; but the prevailing pattern is still very soft, and the smallest elements are not yet stars but small-scale fluctuations in the stellar distribution. The resulting impression is very irritating to the eye. The nebulosity has lost its amorphous character, but nothing definite has yet emerged."

To have known Hubble as a friend and neighboring senior colleague is an experience the writer will long cherish. A bulging file of correspondence covering over 20 years' exchange of information, questions, plans, and results, is like a storehouse in which things seem to retain their freshness indefinitely. To one interested in the same field of research, Hubble was unfailingly helpful and encouraging, for his letters often ended with "Good luck, and any way I can help out, let me know." In replies to questions or requests for information on specific nebulae, his answers were invariably explicit and complete, and frequently gave more than one had ever expected.

His knowledge of individual nebulae was encyclopedic. The 100-odd Messier objects were as familiar to him as the alphabet. He knew literally hundreds of NGC objects in sufficient detail to recall their structure, their relationship to neighboring ones as pairs, multiples, or clusters, and he could suggest the programs for which they might be most useful. He knew the Milky Way, with its complex structure of bright and dark nebulosities, star clusters, planetaries, and nebulous stars, as thoroughly as any port pilot threading his way through a tortuous system of channels, bars, and buoys. On one occasion on Mt. Wilson when a tenderfoot from Berkeley was trying, unsuccessfully, to find an object with the 60-inch, Hubble entered the dome, recognized the militarily fluid situation, sighted along the tube without leaving the floor, and said, "The declination is *plus* five degrees."

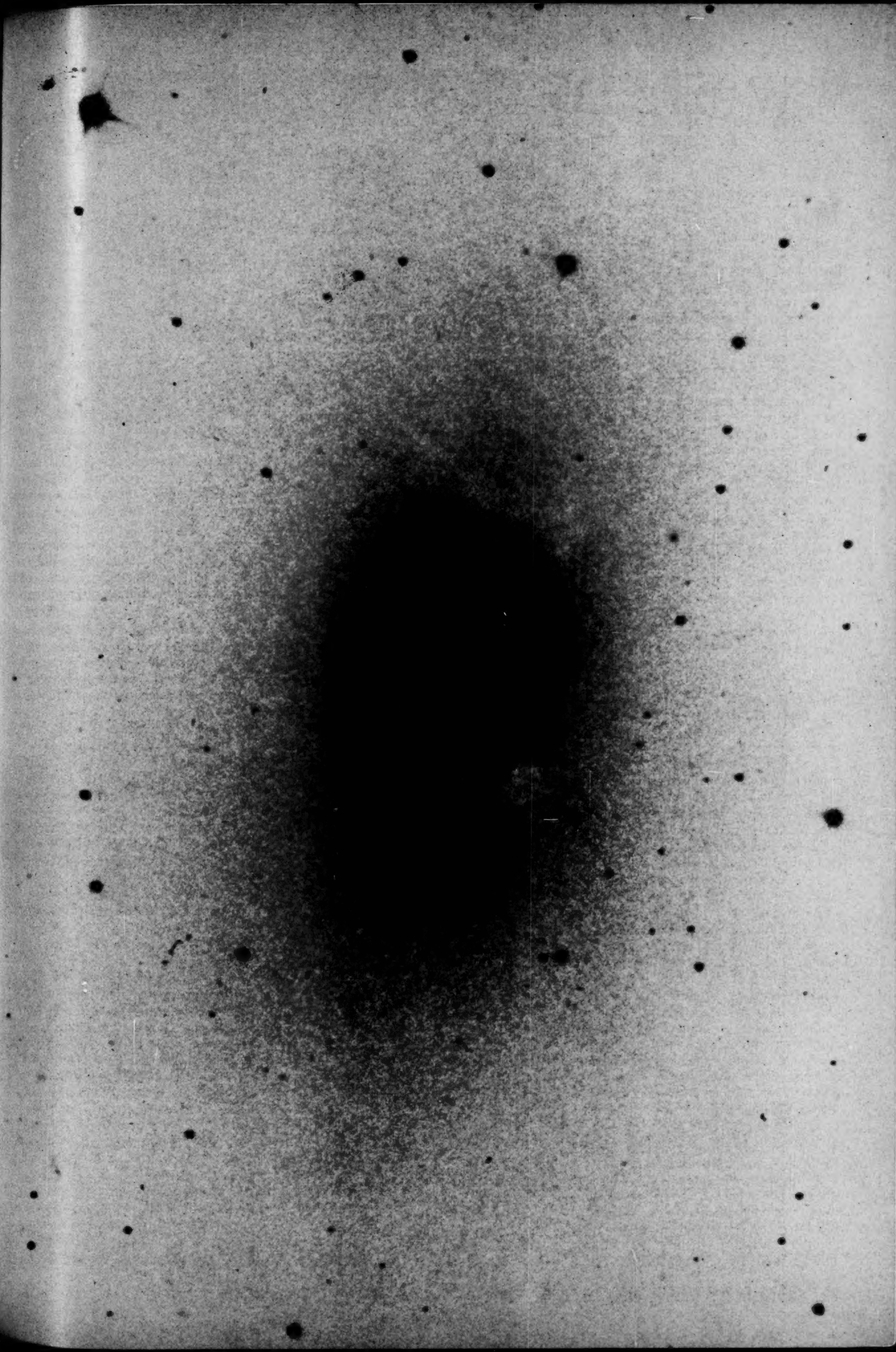
Hubble's letters reveal much more than his kindliness to a younger kindred spirit; they give some insight into the man's character, which fledgling astronomers would do well to study soberly. An example of his calm reaction to criticism is contained in a letter written shortly after publication of his paper on the "Effects of Red Shifts on the Distribution of Nebulae" (1936). His procedure was roundly criticized by some theoretical men, among them Eddington. Hubble wrote, "You will have noticed the field day over the last [his latest paper] in *The Observatory*. Eddington has found his mistake — the higher terms in a series could not be neglected — and his reduction agrees with mine. [. . .] seems to have mishandled the observations, as a theoretical man sometimes does, but I am still waiting to hear from him."

When the 82-inch McDonald reflector was dedicated, Hubble prepared a paper for the related symposium. Despite his previous exhaustive knowledge of innumerable nebular features, he approached the subject anew, with a humble attitude toward more learning: "At the moment I am reviewing the sequence of classification, and attempting to improve my acquaintance with structural forms by a study of 800 Shapley-Ames objects. . . . " From this study he concluded that spiral structure, in the early stages, suggests segregation instead of ejection — a new concept foreshadowing the application in recent years of gas dynamics to the problems of spiral structure.

The problem of finding the direction of rotation of spirals — whether their

(Continued on page 85)

FACING PICTURE: The elliptical galaxy NGC 205, which is a companion of the Andromeda nebula, is shown incipiently resolved in what Dr. Hubble regarded as his best Mount Wilson photograph of this object. This is a negative print from a 100-inch plate taken September 6, 1921, on a Seed 30 emulsion. Note the patches of obscuring matter (light in this reproduction) silhouetted against the galaxy.



WHITE DWARFS--II

By OTTO STRUVE, *Leuschner Observatory University of California*

WE LEARNED last month how directly the observations of the companion of Sirius lead to the result that this star, like other white dwarfs, is abnormally small and extremely dense.

The tremendous mean densities of the white dwarfs suggest that they do not obey the laws of perfect gases. If we should disregard this point and compute the central temperatures based on the gas laws (as we did in our November article for main-sequence stars like the sun), we would obtain approximately one billion degrees! With such an immense temperature the nuclear processes would be extremely active; if hydrogen were present the star would blow up as a hydrogen bomb. But even without hydrogen there would be nuclear processes building up heavier atoms from helium — and these would supply far more radiation than is actually observed in the feeble glow of Sirius B. Its temperature cannot be anything like one billion degrees.

In trying to find the nature of the departure from the law of perfect gases, we are at first led to follow intuition and attribute it to the van der Waals forces, which arise when laboratory gases are compressed to about 100 or 1,000 atmospheres. In this state of compression the atoms, whose diameters are of the order of 10^{-8} centimeter, begin to touch one another. But at the densities of 10^5 to 10^8 that of water which prevail in white dwarfs the atoms are crushed "like eggs packed in the bottom of a heavily laden basket," to use G. Gamow's happy expression.

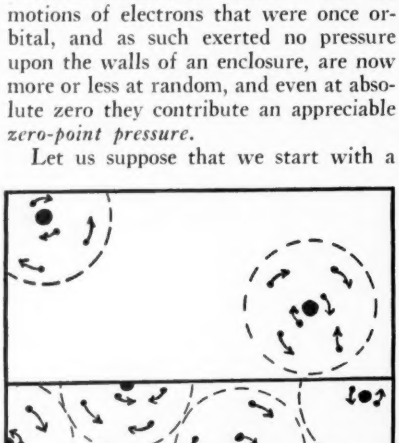
This crushing removes many of the outer electrons from the atoms in the white dwarf's interior and the atoms become heavily ionized. The remaining fragments of atoms occupy individual spheres only of about radius 10^{-12} or 10^{-13} centimeter. We can assume this kind of gas to be compressed to a density billions of times greater than that of water without encountering any difficulty from the actual bodily contact between the atomic fragments. Despite its high density, the substance of a white dwarf is gaseous, and we need not even invoke the high temperature of its interior to account for the necessary degree of ionization to avoid the effect of van der Waals forces.

Why, then, does the ordinary perfect gas law not apply? The answer is found in the theory of *degenerate matter* formulated by E. Fermi and P. Dirac, and applied to white dwarfs by R. H. Fowler and S. Chandrasekhar. The properties of a degenerate gas differ drastically from those of normal gas. Of course, no one has ever obtained such a gas in the laboratory, and our conclusions rest upon theory and such indirect confirmations as may be obtained from an analogous consideration of the problem of the solid state of matter.

Ordinarily, the pressure is proportional to the product of density and temperature. When the temperature is zero absolute, the pressure is also zero — this can be visualized by imagining that the normal full-sized atoms are brought to rest. But in the interior of the atom the orbital motions of the ring electrons are not brought to rest as the temperature drops to zero; even in a completely cold hydrogen atom the electron continues revolving around the proton. Nevertheless, the atom as a whole is at rest with respect to its neighbors.

In the crushed state of matter, however, the free electrons, squeezed off their original atomic nuclei, do not come to rest at zero temperature; they retain vestiges of what were once their orbital velocities around the nuclei. Thus the motions of electrons that were once orbital, and as such exerted no pressure upon the walls of an enclosure, are now more or less at random, and even at absolute zero they contribute an appreciable *zero-point pressure*.

Let us suppose that we start with a vessel containing a small amount of degenerate gas. From the foregoing discussion we know that even at zero temperature the gas exerts a certain pressure. Let us now add more degenerate gas to the vessel, all at zero temperature. The density will, of course, increase. But will the pressure also change? In a perfect gas at zero temperature it would remain always equal to zero.



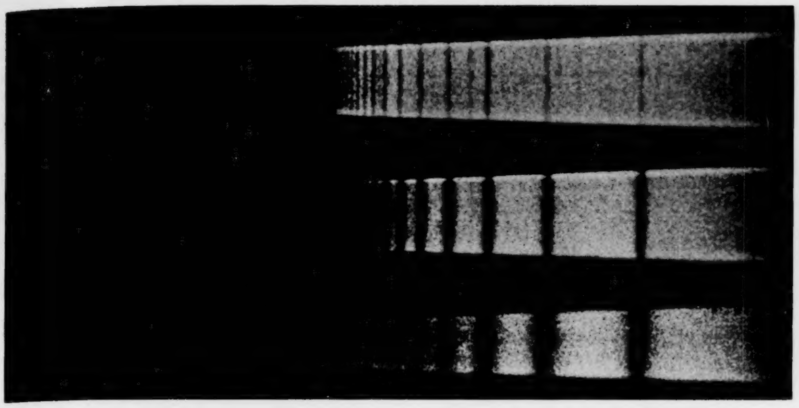
A schematic representation of the gaseous, liquid, and crushed states of matter, according to George Gamow. This diagram is from his book, "Birth and Death of the Sun," Viking Press.

It turns out that by adding more gas to the vessel we of necessity increase the pressure. The argument rests upon Pauli's exclusion principle, which tells us that the newly added electrons cannot duplicate the velocities and spatial locations of electrons already present in the gas. Thus, if the old electrons have the smallest velocities consistent with their original orbital motions, then the new electrons must, on the average, move faster. They increase the zero-point pressure, which is proportional to the 5/3 power of the density and is independent of the temperature. Only for the greatest densities found in the white dwarfs is there a modification in this law; according to Chandrasekhar the pressure then becomes proportional to the 4/3 power of the density. But we shall not use this elaboration, even though it is essential in any accurate computation.

A remarkable property of degenerate stars can be deduced immediately. Consider Sirius B, whose mass is equal to the sun's, and whose mean density is 200,000 times that of water. The mean pressure is given by the law we have just stated: $10^{13} \times 200{,}000^{5/3}$ dynes, if the gas is hydrogen. (The quantity 10^{13} has been computed from quantum theory; see for example L. H. Aller, *Astrophysics*, 1953). It is this internal pressure of the gas that prevents the star from collapsing under its own tremendous gravity, and the size of the star is determined by the balancing of the pressure against the gravity.

To understand the consequences of this situation, let us suppose we pack an additional amount of material, also equal to the sun's mass, into the volume occupied by Sirius B. The density will become twice what it was before. Every cubic centimeter within the star will have twice its former mass, and by Newton's law of universal gravitation will attract every other cubic centimeter with a force that is proportional to the product of their masses; hence, the attraction of the hypothetical star upon itself will be 2×2, or four times as great as in Sirius B.

But the internal pressure will also rise; by the density law above stated it will be $2^{5/3} = 3.2$ times as great as in Sirius B. But this is insufficient to hold the star to its original size because of the four times increase in internal gravity, and the star of twice the sun's mass must therefore contract, until it becomes



These spectra of Deneb, Vega, and 40 Eridani B were taken with a spectrograph constructed by D. Chalonge, of the Institut d'Astrophysique in Paris. The observations were made by R. Canavaggia and V. Kourganoff, with the spectrograph attached to the 82-inch McDonald Observatory reflector. The wedge shape of each spectrum is caused by a pivoted, oscillating plateholder, designed to widen the bright, overexposed part while keeping the weak, ultraviolet portion narrow.

small enough again to establish equilibrium between pressure and gravitation.

The remarkable property we have deduced is that the size of a degenerate star depends inversely upon its mass. In other words, the heavy white dwarfs are smaller than less heavy ones. Chandrasekhar has computed that a white dwarf that consists of pure hydrogen would have a radius of zero were its mass about five suns — there can be no degenerate star of larger mass. A white dwarf consisting entirely of helium, however, cannot have a mass in excess of $1\frac{1}{2}$ times the sun's. This results from the fact that the pressure of a crushed assembly of atoms is given by the number of free electrons. Hydrogen furnishes only one such electron per proton of unit mass, whereas helium has two per alpha particle of mass 4. But the attraction of the star upon itself depends almost entirely upon the atomic nuclei. Therefore, the balance of the two forces, gravitation and pressure, demands a greater reduction in radius in the case of helium than for the lighter hydrogen.

A recent theoretical interpretation of the white dwarfs is contained in two papers by Mestel in the *Monthly Notices* of the Royal Astronomical Society, *112*, pages 583 and 598, 1952. He considers first the energy sources of white dwarfs, and then possible results of their accretion of interstellar matter. Here we are chiefly concerned with the first of these problems.

If we assume that a thin outer skin of a white dwarf consists of ordinary nondegenerate matter, we can compute the pressure and temperature, step by step inward from the surface, using the ordinary laws of perfect gases. At the base of this outside layer the pressure is 10^{18} atmospheres, the density about two kilograms per cubic centimeter, and the temperature about 20 million degrees. Inside this layer the density becomes so great that the gas is degenerate because the atoms are crushed.

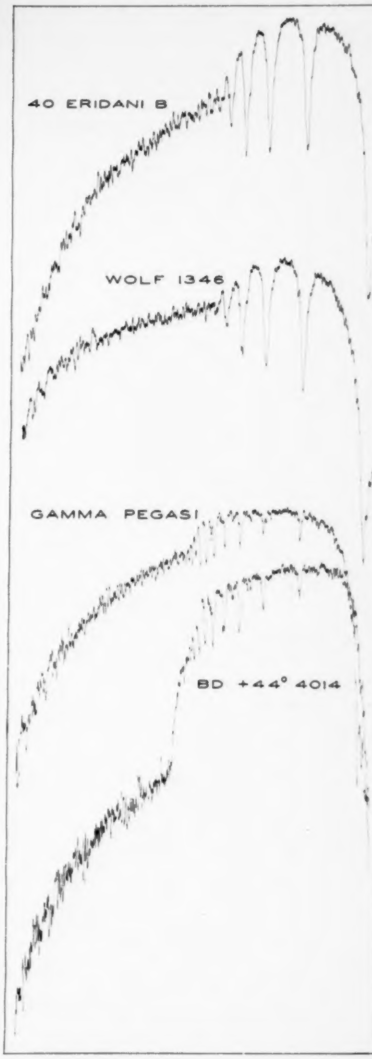
This thin outer layer contains about 1/400 of the total mass of the star, but it forms a blanket of high opacity which limits the rate of cooling of the degenerate core. This layer is subject to the star's high surface gravity, which greatly broadens the lines in its spectrum, as explained last month and as illustrated here; thus, the spectrum gives an important clue to the high density of the star's interior even though it arises only in the surface layer.

For comparison, we have the spectra of three stars of type A: top, the supergiant Deneb; middle, the main-sequence star Vega; bottom, the white dwarf 40 Eridani B. Note the great width of the dark hydrogen lines in the white dwarf spectrum, with the higher members of the series blending into a continuous spectrum long before the Balmer limit at 3647 angstroms is reached. In Deneb, which has narrow lines indicating a low-density, giant star's atmosphere, a large number of the Balmer lines can be distinguished and the sudden Balmer drop at the limit of the series is well shown. This effect is also illustrated by the tracings of four spectra, two of them white dwarfs, that are reproduced here.

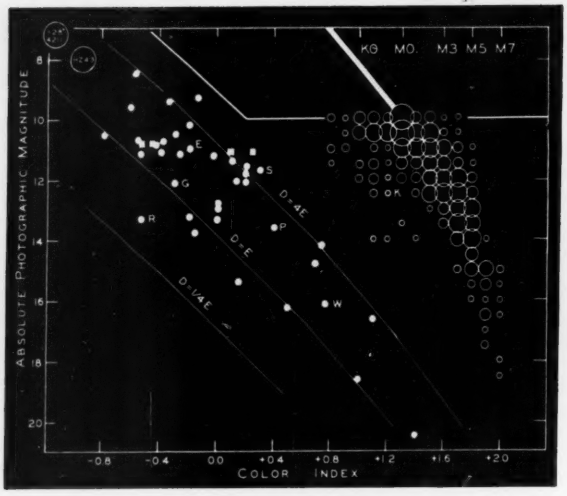
The temperature inside all but the outer one-quarter per cent of the mass differs very little from 20 million degrees. Yet this temperature is ample to convert hydrogen into helium — if hydrogen were present. But so long as nuclear processes are active a star cannot condense to the degenerate state; it must remain similar in constitution to the sun. Mestel concludes that the white dwarfs contain no nuclear energy sources in their interiors, and hence no internal hydrogen, in agreement with Schatzman.

On the other hand, we know that the interstellar clouds consist mostly of hydrogen. Therefore, these peculiar stars cannot have condensed directly out of the interstellar gas into the white dwarf state; they must have been, to begin with, ordinary hydrogen-rich stars (on the assumption that all stars are formed from interstellar matter).

Since the present mass of Sirius B is the same as the mass of the sun, and since nuclear evolution causes only a negligible decrease of mass, by 0.7 per cent, we might think of Sirius B as the kind



Microphotometer tracings of four stars, the upper two white dwarfs, in which the hydrogen-beta line is at the right. The lines through hydrogen-zeta may be seen; the other Balmer lines are blended because of the Stark effect in the dense atmospheres of the white dwarfs. BD +44°4014 shows the normal, sharp appearance of hydrogen lines in main-sequence stars of this type, and the usual Balmer drop at the limit of the series. Gamma Pegasi, which is a B-type star, has relatively weak hydrogen lines and a much smaller Balmer drop.



This is W. J. Luyten's diagram of stars of faint absolute luminosity. On the right are ordinary red dwarfs; to the left are white dwarfs. Stars identified by letter are: E, 40 Eridani B; G, AC +70°8247; P, companion to Procyon; R, Ross 627; S, companion to Sirius; W, Wolf 489. The curves show the locations of stars with diameters four times, equal to, and one fourth the earth's diameter, respectively. University of Minnesota chart.

of star the sun will become after it has converted all its hydrogen into helium. This hypothesis is unsatisfactory, however, because with its slow rate of energy production the sun will require 10^{11} years to reach the stage of hydrogen exhaustion. Yet, in the Hyades cluster we find four white dwarfs and several normal *G* and *K* dwarfs. There are no intermediate types. Since all the cluster members must be approximately the same age — much less than 10^{11} years — this theory is ruled out.

Mestel therefore adopts the hypothesis suggested by F. Hoyle and previously also favored by E. A. Milne, Chandrasekhar, Gamow, and others: What we now observe as a white dwarf was once a very massive *O* or *B* star that rapidly burned up its hydrogen and then, in the final stages of its "perfect-gas" condition, blew off enough material (perhaps in a nova or supernova outburst) to reach the critical mass of 1½ suns for helium, after which it could contract by its own gravitation, eventually reaching the white dwarf state.

A white dwarf radiates energy without replenishment. It contains no hydrogen and is thus deprived of nuclear sources. It cannot contract still further and derive heat by the Helmholtz-Kelvin process, because, as we have seen, its radius is permanently fixed by its present mass. It can only slowly cool, as radiation from its supply of internal heat diffuses outward through its highly opaque "perfect-gas" skin, at a rate which will maintain the star's present low luminosity for 10^9 years.

Now let us turn to Luyten's H-R diagram for faint stars. Open circles represent ordinary dwarfs (at the lower end of the main sequence), dots the white dwarfs, and square dots are the four Hyades white dwarfs. Each white dwarf is observed at only one brief moment of its existence, but all of them taken together are believed to give a picture of the evolution (or "aging") of these stars. The situation is far simpler than elsewhere in the H-R diagram, because surface temperature, becoming less and less as the white dwarf cools, is the only variable factor.

Thus, the location of such a star along Luyten's sequence depends on its surface temperature, and hence on its age: The oldest and reddest stars are on the right-hand end of the band. Stars of greater mass have smaller radii and lie farther to the left and lower. Those along the lower edge have diameters of the order of half that of the earth, and their masses are near 1½ suns, the maximum for white dwarfs made of helium. Stars near the upper edge of the band are about four times as large as the earth, with masses about half the sun's.

It will be noticed in Luyten's diagram that the white dwarf sequence and the main sequence are not quite parallel. Theoretically, the luminosity of a main-sequence star is proportional to the 5½ power of its effective surface temperature. But a white dwarf cools without change in radius, so that its luminosity will remain proportional to the fourth power of the temperature, in obedience to Stefan's law. As a result, the two sequences should have different slopes, and there is excellent agreement between observation and theory.

MERCURY TRANSIT ROUNDUP

(Continued from page 76)

much information about the black drop could be gained from laboratory experiments with rather simple equipment.

Abnormal phenomena sometimes noted at earlier transits include bright spots on Mercury, and light or dark aureoles surrounding the planet, but such appearances have long been classed as illusory. On November 14th several observers looked carefully for these effects without seeing them. The absence of any halo is specifically stated by Lonzo Dove, who observed with a 4-inch refractor at Broadway, Va. At Weston, Mass., the writer with a 3-inch, 100x refractor could see neither bright spot nor aureole.

In agreement with this, the absence of any unusual phenomena between contacts II and III was noted by Dr. R. D. Levee, J. Reed, and W. Beavers at the Laws Observatory, with 7½-inch, 4¼-inch, and 2⅞-inch refractors. While a grayish halo around Mercury was seen by O. C. Ranck and W. A. Azinger at Milton, Pa., they attributed it to the heavy overcast through which the sun was seen.

One valuable result of the transit was in the field of astronomical public relations. A transit of Mercury is an admirable object for public demonstration.

The opportunity was well used. At Toronto, the local section of the Royal Astronomical Society of Canada arranged advance newspaper publicity, showing the event through five telescopes to over 200 people. At the Buhl Planetarium in Pittsburgh, the 10-inch siderostat projected the image of the sun on a screen for the public. The Amateur Telescope Makers of Boston set up instruments at the Boston Museum of Science, which is located on the Charles River dam, an ideal site for observing that is close to the heart of the city. Other groups were organized at the Adler Planetarium, and by the amateurs in Rochester, and many school and college observatories used this opportunity to give a live display to students. Probably there was hardly an amateur who set up his telescope in his yard for the transit who did not have friends and passers-by stop for a view.

The top row of these drawings by S. L. O'Byrne, of St. Louis, shows the thin hairline of light seen at 18:08:14 UT, before third contact, the sharply pointed horns of light visible after the hairline was broken, and Mercury's appearance at 18:08:33 UT. The lower sketches show Mercury before last contact; the disappearance of the wedge-shaped notch occurred at 18:11:38½ UT.

In many ways, the November 14, 1953, transit of Mercury was a conspicuous success, as far as weather permitted. And even the relatively few observers who were clouded out hold rain checks bearing the date of November 7, 1960, for the next transit visible from North America.

J. A.

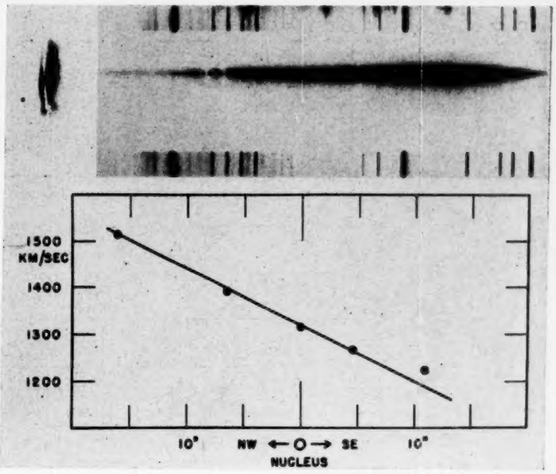
EDWIN HUBBLE

(Continued from page 80)

arms trail or lead—required considerable correspondence with Hubble. It was fairly easy to obtain the spectroscopic sense, but the orientation in space of the spiral pattern was a matter on which it appeared difficult to reach agreement. Two years before his paper was published (1943), Hubble selected what he considered the best test object, NGC 3190, and with characteristic vigor and enthusiasm he secured the necessary spectroscopic and direct photographic material with the 100-inch. He wrote, "I have just made a 16-hour exposure on 3190. The S.F. end is approaching and the N.P. end is receding (with respect to the nucleus). The rotation is conspicuous, so there seems to be no reasonable doubt that *this spiral is trailing its arms.* A recent long-exposed, direct photograph brought out the faint extensions, which fix the direction of the spiral pattern." It must have given him much satisfaction to learn, within the past year or two, that the spiral arms just beginning to be traced in our galaxy, by both optical and radio astronomy, likewise appear to trail.

As a result of his galaxy counts to the faintest limits attainable with the 100-inch, Hubble foresaw that only a moderate increase in light-gathering power would yield photographs in which the number of distant objects would exceed the number of foreground stars normally found in medium to high galactic latitudes. On his best 100-inch plates (the one of NGC 3190 is mentioned above), his prediction of more nebulae than stars came close to fulfillment. It is hardly necessary to add that the 200-inch has yielded many plates on which faint extragalactic nebulae outnumber galactic stars.

This tribute to Hubble's achievements has only highlighted a small portion of his contributions to astronomy, and that in a personal, probably not unbiased way. A stimulating and rewarding association of 25 years cannot be viewed dispassionately; the feeling is one of gratitude for having had the privilege of closeness to a truly great scientist. Perhaps the perspective of time is needed for a less subjective view, but it is tempting to think that Hubble may have been to the observable region of the universe what the Herschels were to the Milky Way system, and what Galileo was to the solar system. Whatever history's judgment, there is little doubt that Edwin Hubble was a master mariner in his "realm of the nebulae."



How the rotation of NGC 3190 was determined is shown here. On one side of the nucleus, the rotation produces a relative motion of approach, and the spectral lines are shifted to the violet with respect to those on the other side of the nucleus. The change of relative velocity with reference to distance from the center of the system shows that the measurable parts of this system rotate like a wheel.

GRAPHIC TIME TABLE OF THE HEAVENS--1954

REPRODUCED on the following pages is a chart published annually by the Maryland Academy of Sciences, through whose courtesy the engraving has been lent for our use. Separate copies may be obtained from the Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., for 25c each; on orders of 20 or more the price is 15c each. Large wall charts, 40 by 27 inches, are $1.00.

Using the Graphic Time Table

The Graphic Time Table gives the rising and setting times of the sun, moon, and bright planets, the duration of twilight, times when certain stars and other objects of interest transit (cross the meridian), the moon's phases, the equation of time, and other astronomical information. Following the line for any day horizontally across the chart, one can read off the times of various events as the horizontal line intersects any of the curves. Time is shown by the vertical lines to the half hour, and more precise times may be determined by interpolation. The curve for the equation of time shows how much the sun is fast if the curve is to the left of the midnight line, and slow if it is to the right. When the sun is fast, it arrives at the meridian before 12 o'clock noon, local time, by the amount shown.

The dashes on the sunset and sunrise curves aid interpolation on intermediate days. Roman numerals show sidereal time at midnight. The vernal equinox transit line is shown; this indicates the exact civil or ordinary time of zero hours sidereal time. Small numbers at the left give the Julian day. Small black circles show moonset for the first half of the lunar month, and small open circles show moonrise from full to new moon.

The scale at the right is for finding rising or setting times of other objects. Set dividers or a strip of paper from the index at the center of the scale to the object's declination, north or south (which must be known), and in the direction desired for either rising or setting. Measure this same distance along the midnight line of the chart beginning at the proper right ascension indicated by the Roman numerals. Should this end point fall outside the chart, add to or subtract from the right ascension 12 hours and reset the dividers using the end of the scale rather than the center index. Through the point established, draw a line parallel to the vernal equinox line on the chart. This will show the time of the rising or setting of the object.

The Events of a Single Night

As an example, consider the night of January 7-8 by following the horizontal line for that date across the chart from left to right: The Julian Day number is 2,434,750; the sun sets at 4:51 p.m.; evening twilight ends at 6:27; the upper culmination or transit of Polaris is at 6:42; the moon, three days past new, sets at 8:03; transit of the Pleiades is at 8:37, of Jupiter at 10:00, and of the Orion nebula at 10:25; the sidereal time at midnight is $7^h\ 08^m$; the curve for the equation of time shows that the sun is slow, and will not arrive at the meridian until six minutes after 12 o'clock noon, local time, January 8th. Saturn rises at 1:51 a.m. and Mars at 2:11; Jupiter sets at 5:20; morning twilight begins at 5:46; Polaris crosses the lower meridian at 6:41; Venus rises at 7:06; Saturn transits at 7:13; Mercury rises at 7:17, followed by the sun at 7:22; Mars transits at 7:26 a.m.

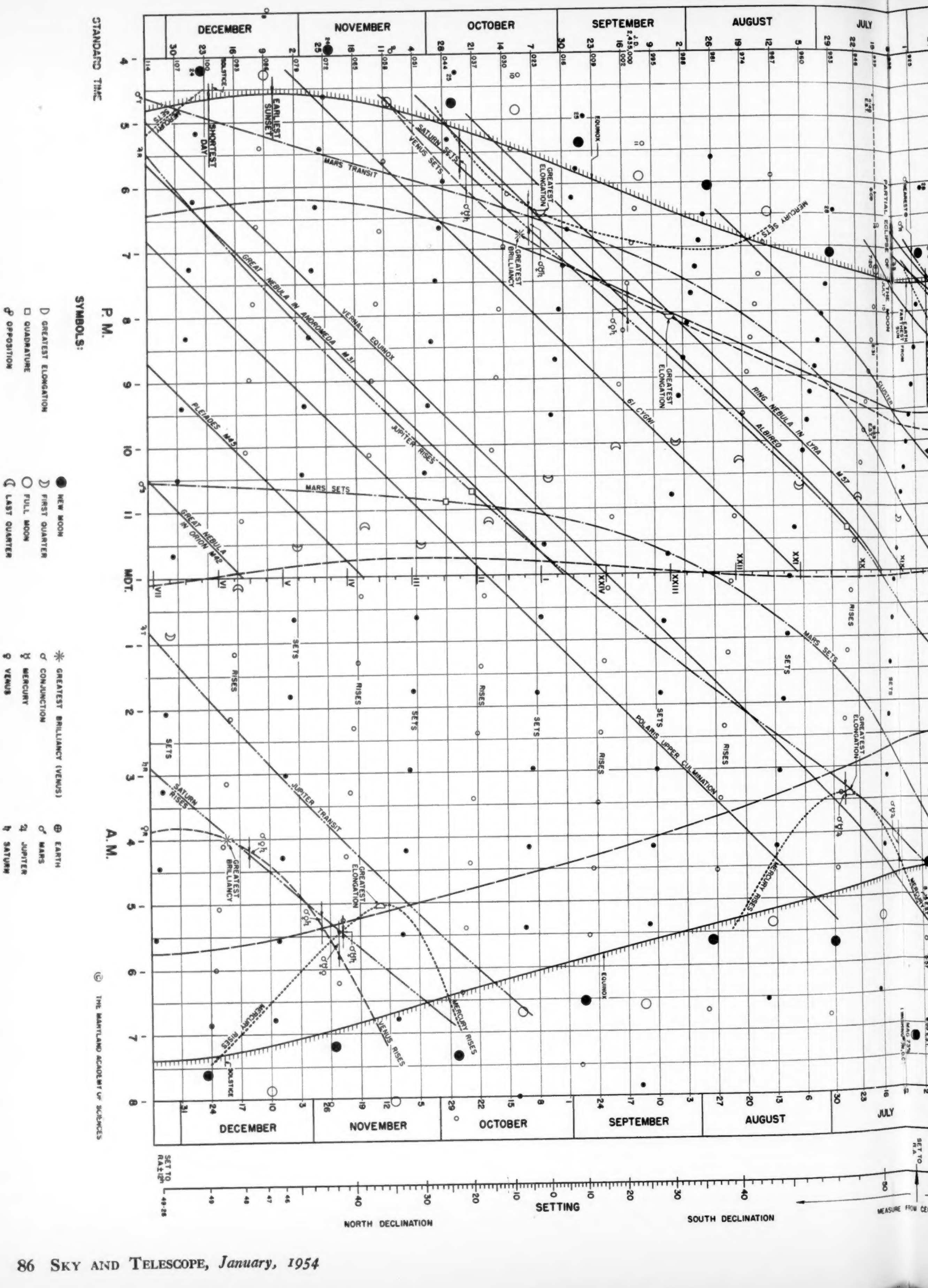
How to Correct for Your Position

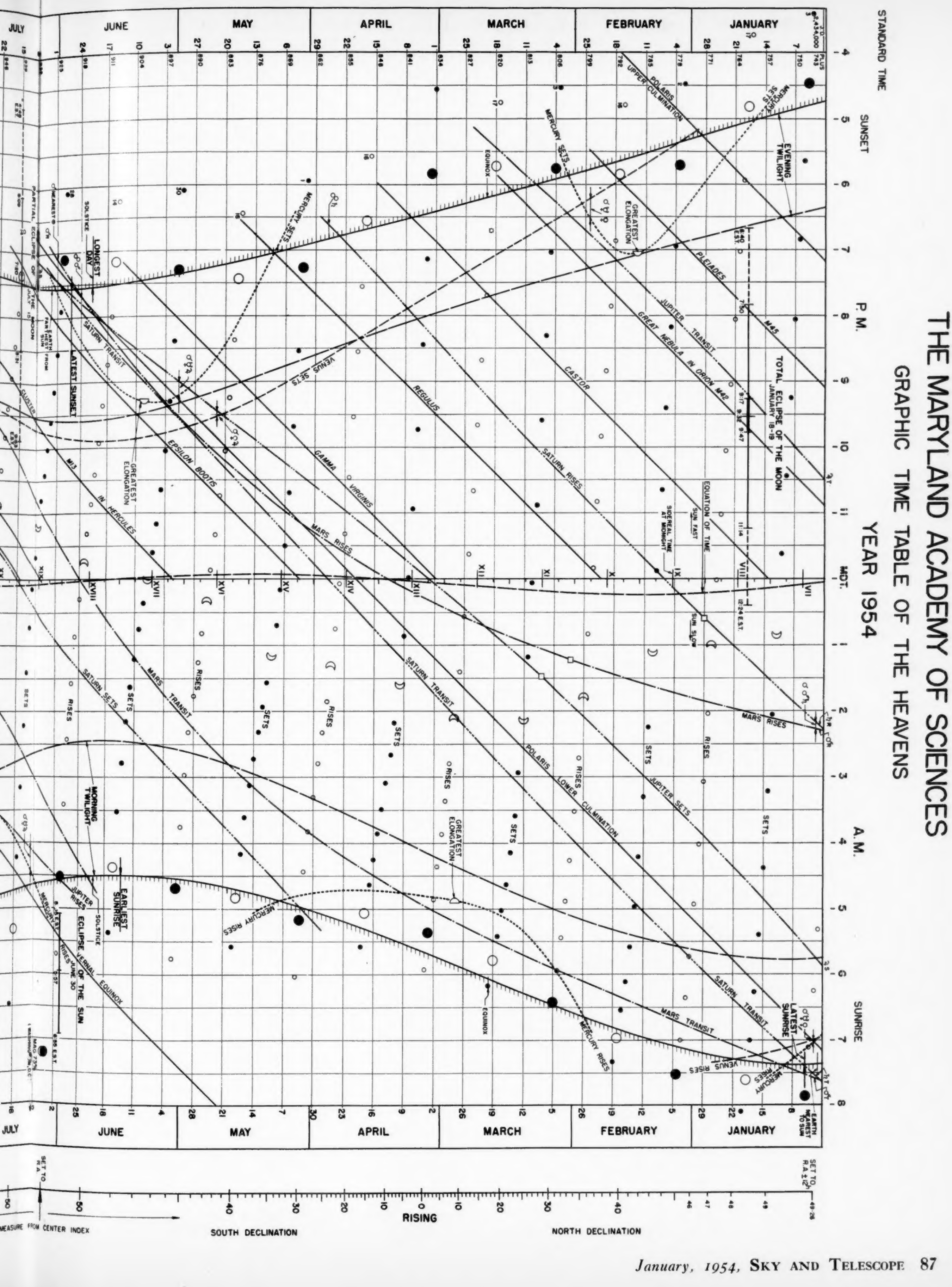
As in all almanacs, times of rising and setting of sun, moon, and planets are absolutely correct for only one point on the earth's surface—for this chart: latitude 40° north and longitude 90° west. The observer may easily correct for his own position. Latitude differences have comparatively minor effect and may in general be disregarded in this country.

Correction for differences in longitude depends principally on the observer's distance east or west of his standard time meridian, which is always at an even multiple of 15°. Some corrections are tabulated here, in minutes of time:

Atlanta +38	Kansas City +18
Baltimore +6	Los Angeles —7
Boston —16	Milwaukee —8
Chicago —10	Minneapolis +13
Cincinnati +38	New York —4
Cleveland +27	Pittsburgh +20
Denver 0	Rochester +10
Detroit +32	Seattle +10
Houston +22	St. Louis +1
Indianapolis —16	Washington +8

All places with plus corrections are west of the standard meridian, and the events will occur later. The usual correction of one hour for each standard time zone must also be made to the Eastern standard times given for specific events, such as the three eclipses.


STANDARD TIME
P. M.
A. M.
MDT.
DECEMBER
NOVEMBER
OCTOBER
SEPTEMBER
AUGUST
JULY
EARLIEST SUNSET
SHORTEST DAY
SOLSTICE
EQUINOX
MARS TRANSIT
SATURN SETS
VENUS SETS
MERCURY SETS
GREATEST ELONGATION
GREATEST BRILLIANCY
GREAT NEBULA IN ANDROMEDA M31
VERNAL EQUINOX
JUPITER RISES
61 CYGNI
RING NEBULA IN LYRA M57
ALBIREO
PLEIADES M45
MARS SETS
GREAT NEBULA IN ORION M42
POLARIS UPPER CULMINATION
JUPITER TRANSIT
SATURN RISES
VENUS RISES
MERCURY RISES
PARTIAL ECLIPSE OF THE MOON
RISES
SETS
SYMBOLS:
NEW MOON
FIRST QUARTER
FULL MOON
LAST QUARTER
GREATEST ELONGATION
QUADRATURE
OPPOSITION
GREATEST BRILLIANCY (VENUS)
CONJUNCTION
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
© THE MARYLAND ACADEMY OF SCIENCES
SET TO R.A.+12h
SETTING
NORTH DECLINATION
SOUTH DECLINATION
MEASURE FROM CE


THE MARYLAND ACADEMY OF SCIENCES
GRAPHIC TIME TABLE OF THE HEAVENS
YEAR 1954
STANDARD TIME
SUNSET
P.M.
MDT.
A.M.
SUNRISE
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
EVENING TWILIGHT
MORNING TWILIGHT
POLARIS UPPER CULMINATION
POLARIS LOWER CULMINATION
PLEIADES
M45
JUPITER TRANSIT
JUPITER SETS
GREAT NEBULA IN ORION M42
CASTOR
REGULUS
GAMMA VIRGINIS
EPSILON BOOTIS
M13 IN HERCULES
SATURN RISES
SATURN TRANSIT
SATURN SETS
MARS RISES
MARS TRANSIT
MERCURY SETS
MERCURY RISES
VENUS SETS
VENUS RISES
GREATEST ELONGATION
TOTAL ECLIPSE OF THE MOON JANUARY 18-19
PARTIAL ECLIPSE OF THE MOON
ECLIPSE OF THE SUN
EQUATION OF TIME
SUN FAST
SUN SLOW
SIDEREAL TIME AT MIDNIGHT
EQUINOX
VERNAL EQUINOX
SOLSTICE
LONGEST DAY
LATEST SUNSET
EARLIEST SUNRISE
LATEST SUNRISE
EARTH NEAREST TO SUN
EARTH FARTHEST FROM SUN
SET TO R.A.
SET TO R.A. ± 12h
RISING
MEASURE FROM CENTER INDEX
SOUTH DECLINATION
NORTH DECLINATION

HERE AND THERE WITH AMATEURS

*Members receive *Sky and Telescope* as a privilege of membership. †Member organizations of the Astronomical League.

State	*City*	*Organization*	*Time*	*Meeting Place*	*Communicate With*
ARIZONA	Phoenix	*Phoenix Obs. Ass'n	7:30, 1st, 3rd Tue.	Private homes	R. D. Smith, Jr., 6635 N. Central Ave.
CALIFORNIA	Fresno	*Central Val. Ast'mers	7:45, 2nd Mon.	Fresno Coll., homes	Elizabeth Dean, 409 Shields (4)
	Kentfield	*Marin Am. Ast.	8:00, 4th Fri.	Marin College	V. S. Yoder, 48 Mercury Ave., Mill Valley
	Long Beach	†*Excelsior Tel. Club	7:30, 3rd Fri.	Art Center	T. R. Cave, Jr., 265 Roswell Ave. (3)
	Los Angeles	L.A.A.S.	7:45, 2nd Tue.	Griffith Obs.	G. Carroll, 7114 Summitrose St., Tujunga
	Oakland	*Eastbay A.S.	8:00, 1st Sat.	Chabot Obs.	Mary Grissom, 79 Bayo Vista (11)
	Palo Alto	*Peninsula A.S.	7:30, 1st Fri.	Community Center	H. W. Milner, 350 Tennyson Ave.
	Redlands	*Redlands A.S.	7:30, Tues.	Univ. of Redlands	Miss R. Schweikert, 111 Prospect Dr.
	Sacramento	*Sac. Val. A.S.	8:00, 1st Tue., bi-mon.	Sacramento College	Mrs. E. Champ, 3816 Sacramento Blvd. (17)
	San Diego	Ast. Soc. of S.D.	7:30, 1st Wed.	504 Electric Bldg.	W. T. Skilling, 3140 Sixth Ave.
	San Diego	A.T.M. Ast. Club	7:30, 2nd, 4th Mon.	3121 Hawthorn St.	Al Nelson, 3121 Hawthorn St.
	San Francisco	*S.F. Am. Ast'mers	8:00, 1st Wed.	Randall Junior Mus.	H. A. Wallace, 2925A Jackson St.
	Stockton	*Stockton A.S.	8:00, 2nd Mon.	Stockton College, C-3	Dr. C. P. Custer, 155 E. Sonoma Ave.
COLORADO	Denver	†*Denver A.S.	8:00, 2nd, 4th Fri.	Chamberlin Obs.	John Boatright, 1400 S. Clayton, RA-0375
CONNECTICUT	Middletown	*Centr. Conn. A.A.	8:00, 1st Tue.	Van Vleck Obs.	Walter Fellows, Middle Haddam
	New Haven	†A.S. of New Haven	8:00, 4th Sat.	320 York St.	Florence Welter, 77 Spring Rd., N'th Haven
	Norwalk	*Perkin-Elmer AA&TM	5:00, 1st, 3rd Wed.	Perkin-Elmer plant	J. Vrabel, Bob White Lane, Wilton
	So. Norwalk	†Fairfield Co. A.S.	8:00, Alt. Fri.	Private homes	Goldie L. Grantham, 58 Bouton St.
	Stamford	Stam. Museum A.A.	8:00, 3rd Fri.	Stamford Museum	R. F. Ives, Post Rd. East, Darien
DIST. COL.	Washington	†Nat'l. Cap. Ast'mers	8:00, 1st Sat.	Comm. Dept. Audit.	Miss G. Scholz, 110 Schuyler Rd., Sil. Spg., Md.
FLORIDA	Daytona Beach	D. B. Stargazers	8:00, Alt. Mon.	105 N. Halifax Ave.	Wm. T. Thomas, 105 N. Halifax
	Jacksonville	†*J.A.A.C.	8:00, 1st, 3rd Mon.	Private homes	E. L. Rowland, Jr., 442 St. James Bldg.
	Key West	†Key West A.C.	8:00, 1st Wed.	Private homes	J. M. Martin, 1605 United St.
	Miami	†*South'n Cross A.S.	7:30, 3rd Mon.	Central School	A. P. Smith, Jr., 426 S.W. 26 Rd.
	Miami Springs	†*Gulfstream A.A.	8:00, 4th Fri.	Boys Club, 2805 SW32Av.	L. G. Pardue, 641 Falcon, 88-5434
	Patrick AFB	Banana River A.S.	8:00, 2nd Wed.	Civilian Personnel Bldg.	Lt. R. W. Edelen, Box 669, Patrick AFB
	Pensacola	†Pensacola A.A.C.	7:30, 3rd Mon.	Private homes	Frank Dachille, 1781 E. Baars St.
	St. Petersburg	St. P'burg A.A.C.	7:30, 4th Thu.	Museum Auditorium	Dr. R. E. Angell, 233 5th Ave. N.
GEORGIA	Atlanta	†*Atlanta A.C.	7:30, 2nd Fri.	Agnes Scott College	W. H. Close, 225 Forkner Dr., Decatur
ILLINOIS	Chicago	†*Burnham A.S.	4:00, 2nd Sun.	Adler Planetarium	J. A. Anderer, 7929 S. Loomis Blvd. (20)
	Geneva	*Fox Valley A.S.	8:00, 1st Tue.	Geneva City Hall	Joseph Zoda, 420 Fellows St.
	Moline	†*Popular A.C.	7:30, Wed.	Sky Ridge Obs.	Carl H. Gamble, 3201 Coaltown Rd.
	Peoria	Ast. Sec., Acad. Sci.	8:00, 2nd Wed.	Peoria Hts. School	R. P. Van Zandt, 156 N. Eleanor Pl. (5)
INDIANA	Indianapolis	†*Indiana A.S.	2:15, 1st Sun.	Riley Library	W. E. Wilkins, 6124 Dewey Ave. (19), IR-5946
	South Bend	*St. Jos. Valley Ast.	8:00, 1st Mon.	1144 W. Western Ave.	E. J. Gabrich, 1518 S. Webster St. (14)
KANSAS	Wichita	†*Wichita A.S.	8:00, 1st Wed.	214 East High Sch.	S. S. Whitehead, 2322 E. Douglas, 62-6642
KENTUCKY	Louisville	†L'ville A.S.	8:00, 1st Tue.	Univ. of Louisville	B. F. Kubaugh, 207 Sage Rd. (7)
LOUISIANA	Gretna	Gretna A.S.	7:00, Alt. Wed.	Private homes	John A. Gunther, 209 Newton St.
	Lake Charles	Lake Charles A.A.C.	7:30, 2nd Tue.	Ass'n. Commerce Bldg.	Norman G. Lore, 532 Alamo St.
	New Orleans	A.S. of N.O.	8:00, Last Wed.	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
MAINE	Portland	†A.S. of Maine	8:00, 2nd Fri.	Private homes	H. Harris, 27 Victory Ave., S. Portland
MASSACHUSETTS	Cambridge	†*Bond A.C.	8:00, 1st Thu.	Harvard Obs.	R. Smith, 519 Quincy Shore Dr., No. Quincy 71
	Cambridge	†*A.T.M.s of Boston	8:00, 2nd Thu.	Harvard Obs.	John Patterson, 142 Elgin, Newton Center 59
	Cambridge	*M.I.T. A.S.	7:30, Alt. Wed.	Mass. Inst. Tech.	R. L. White, Box 162, 3 Ames St.
	Springfield	†*S'field•Stars	8:00, 2nd Wed.	Private homes	J. E. Welch, 107 Low'r B'verly Hills, W. S'field
	Worcester	†*Aldrich A.S.	7:30, 1st, 3rd Tue.	Mus. Natural Hist.	W. C. Lovell, 24 Courtland (2), 3-1559
MICHIGAN	Ann Arbor	†Ann Arbor A.A.A.	7:30, 2nd Mon.	U. of Mich. Obs.	Stewart W. Taylor, 1106 Birk Ave.
	Battle Creek	†B. C. Ast. Club	8:00, 2nd Fri.	Kingman Museum	Mrs. W. V. Eichenlaub, 47 Everett St.
	Detroit	†*Detroit A.S.	2:30, 2nd Sun.	Wayne U., State Hall	E. R. Phelps, Wayne University
	Kalamazoo	†Kalamazoo A.A.A.	8:00, Sat.	Private homes	Mrs. G. Negrevski, 2218 Amherst, 31482
	Lansing	†*Lansing A.A.	8:00, Fri.	No. 8 Fire Station	Edward H. Carlson, 2111 Grant St. (10)
	Pontiac	†*Pon.-N.W. Det. A.A.	3:00, 3rd Sun.	Cranbrook Inst.	G. Carhart, 40 Hadsell Dr., FE 2-9980
MINNESOTA	Minneapolis	M'polis A.C.	7:30, 1st Wed.	Public Library	Anna Klint, 2526 Garfield Ave. S. (5)
	St. Paul	†*St. Paul Tel. Club	7:30, 2nd, 4th Wed.	Macalester Coll.	Mrs. R. E. English, 1283 Sargent Ave.
MISSOURI	Fayette	†*Central Mo. A.A.	7:30, 3rd Sat.	Morrison Obs.	R. C. Maag, 816½ S. Mass., Sedalia
	Kansas City	†*A.C. of Kans. City	8:00, 4th Sat.	K. C. Museum	Mrs. Laura Kinsey, 4604 Jefferson (2)
	St. Louis	†*St. Louis A.A.S.	8:00, 3rd or 4th Fri.	Inst. of Tech., St. L. U.	S. O'Byrne, 501 E. Pacific, Webster Groves 19
NEVADA	Reno	A.S. of Nev.	8:00, 4th Wed.	Univ. of Nevada	E. W. Harris, University of Nevada
NEW JERSEY	Caldwell	West Essex A.A.	8:00, 2nd Mon.	Caldwell Mun. Bldg.	Walter J. Adams, 18 Thomas St.
	Jersey City	†Revere Boys Club	7:15, Mon., Tue.	Gregory Mem. Obs.	Enos F. Jones, 339 Wayne St.
	Roselle Park	†A.A.S. of Union Co.	....., 4th Fri.	Boro Hall	Mrs. R. N. Bochau, 236 Normandy Vill., Union
	Rutherford	A.S. of Rutherford	8:00, 1st Thu.	YMCA	W. B. Savary, 78 W. Pierrepont Ave.
	Teaneck	†Bergen Co. A.S.	8:30, 2nd Wed.	Obs., 107 Cranford Pl.	J. M. Stofan, 332 Herrick
NEW MEXICO	Las Cruces	†*A.S. of L.C.	....., 1st Sat.	Private homes	C. W. Tombaugh, 636 S. Alameda
	Roswell	*Pecos Val. S&TC	7:30, 2nd Fri.	Cha. of Comm.	Dr. R.R. Boyce, Rt. 2, Box 163A
NEW YORK	Buffalo	†*Buffalo A.A.	7:30, 1st Wed.	Mus. of Science	Dr.F.S.Jones,83Briarcliffe,Cheektowaga(25)
	Corning	Corning A.C.	8:00, 1st, 3rd Mon.	Corning Glass Center	W. R. Redmond, 119 E. 2nd St.
	Gloversville	†*A.C. of Fulton Co.	....., ...	....	L. R. Ogden, 60 W. Pine St.
	New York	*A.A.A.	8:00, 1st Wed.	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., TR 3-1300
	New York	†Junior A.C.	8:00, 3rd Fri.	Bklyn Public Library	J. Rothschild, Hayden Plan., TR 3-1300
	Rochester	†Ast. Sec., Acad. Sci.	8:00, 1st Fri.	Rochester Museum	Louise Zeitler, 91 Hickory St. (20)
	Schenectady	†*S'tady A.C.	7:30, 3rd Mon.	Nott Terrace H. S.	C. E. Johnson, 102 State St.
	Troy	*Renss. Ap. Soc.	7:30, Alt. Tue.	Sage Lab., R.P.I.	Dr. Robert Fleischer, R.P.I.
	Utica	†*Utica Am. Ast'mers	7:30, 4th Tue.	Proctor Inst.	John Zimm, 239 Thieme Pl.
	Wantagh	Long Island A.S.	8:00, Sat.	Private homes	A. R. Luechinger, Seaford Ave., 1571
N. CAROLINA	Greensboro	†*Greensboro A.C.	8:00, 2nd Wed.	Woman's Coll., U.N.C.	Mrs. J. Bradshaw, Guilford College, N.C.
	Raleigh	†Astronomical Soc.	....., 1st, 3rd Thu.	N. C. State Coll.	Richard C. Davis, Sch. of Textiles
	Winston-Salem	†*Forsyth A.S.	7:30, Last Fri.	Private homes	Kenneth Shepherd, 1339 W. 4th St.
NORTH DAKOTA	Grand Forks	*Red River A.C.	8:00, 2nd, 4th Mon.	City Hall	L. G. Peck, 2101 1st Ave. North
OHIO	Akron	*A.C. of Akron	8:00, Last Fri.	St. Peter's Epis. Church	Mrs. R. J. Couts, 878 Kennebec Ave. (5)
	Cincinnati	*Cin. A.A.	8:00, Various days	Cincinnati Obs.	Robert Berkmeier, 2432 Ohio Ave.
	Cincinnati	*Cin. A.S.	8:00, 3rd Wed.	5556 Raceview Ave.	John Dann, 3318 Felicity Dr. (11)
	Cleveland	†Cleveland A.S.	8:00, Fri.	Warner & Swasey Obs.	Mrs. Helen Strohm, Warner & Swasey Obs.
	Columbus	*Columbus A.S.	8:00, 2nd Sat.	McMillin Obs.	Miss R. A. Charlton, 1361 E. 22 Ave. (11)
	Dayton	A.T.M.s of Dayton	Eve., 3rd Sat.	Private homes	F. E. Sutter, RR 7, Box 253A (9)
	Lorain-Elyria	*Black River A.S.	7:30, 1st Wed.	Spang Bldg.	Louis Rick, Box 231, Lorain
	Marietta	Marietta A.S.	Irregular	Cisler Terrace	Miss L. E. Cisler, Cisler Terrace
	Toledo	Toledo Ast. Club	....., 3rd Tue.	Univ. of Toledo Obs.	E. D. Edenburn, 4124 Commonwealth Ave.
	Warren	Mahoning Val. A.S.	8:00, Thu.	Private homes	S. A. Hoynos, 1574 Sheridan, NE, 25034
	Youngstown	*Y'town A.C.	7:30, 1st Fri.	Homestead Pk. Pav'n.	F. W. Hartenstein, 905 Brentwood
OKLAHOMA	Tulsa	†*Tulsa A.S.	7:30, 1st Sat.	Private homes	R. L. Frossard, 4218 E. 25th Ave.
OREGON	Portland	†*Portland A.S.	8:00, Tue.	Journal Bldg.	H. J. Carruthers, 427 S.E. 61 Ave.
	Portland	†A.T.M. & Observers	8:00, 2nd Tue.	Private homes	Miss M. Edgar, 1626 S.E. Neholem (2)
PENNSYLVANIA	Beaver	†*Beaver Co. A.A.A.	8:00, 4th Tue.	Com'y Bldg., Tamaqui	Mrs. R. T. LuCaric, Box 463, Baden
	Millvale	A.A.A. Shaler T'ship	8:00, 3rd Fri.	Cherry City Fire House	Cliff Raible, Rebecca Sq. (9)
	Philadelphia	†A.A. of F.I.	8:00, 3rd Fri.	Franklin Institute	Edwin F. Bailey, LO 4-3600
	Philadelphia	†*Rittenhouse A.S.	8:00, 2nd Fri.	Franklin Institute	John Streeter, LO 4-3600
	Pittsburgh	†*A.A.A. of P'burgh	8:00, 2nd Fri.	Buhl Planetarium	Mary Burcik, 315 Moore Ave. (10)
	Pottstown	†Pottstown A.A.C.	7:30, Fri.	Public Library	W. E. Schultz, Public Library
RHODE ISLAND	Providence	Skyscrapers, Inc.	8:00, Mon. or Wed.	Ladd Observatory	Ladd Obs., Brown U., Jackson 1-5680
TENNESSEE	Chattanooga	†*Barnard A.S.	8:00, 3rd Fri.	Jones Observatory	A. H. Jones, 411 W. 21st St., 5-1646
	Memphis	†Memphis A.S.	8:00, 1st Fri.	Memphis Museum	J. M. Buhler, 3796 Central Ave.
	Nashville	*Barnard A.S.	7:30, 2nd Thu.	Dyer Observatory	Miss J. Saffer, 446 Humphrey St. (10)

Amateur Astronomers

THIS MONTH'S MEETINGS

Buffalo, N. Y.: Buffalo Astronomical Association, 7:30 p.m., Museum of Science. Jan. 6, E. Wallmeyer, "Celestial Photography"; J. Ballantyne, "Solar Energy."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Jan. 22, Dr. Martin Schwarzschild, Princeton University Observatory, "Past and Present of the Stars."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Lone Star Gas Co. auditorium. Jan. 25, astronomical film.

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. Jan. 12, Prof. Clarence R. Smith, Aurora College, "Topics in Optics—From the Notes of a Physics Teacher."

Lansing, Mich.: Lansing Amateur Astronomers, 8 p.m., No. 8 Fire Station. Jan. 17, Christine Culp, "Stars and Constellations Visible from the Northern Hemisphere."

Minneapolis, Minn.: Minneapolis Astronomy Club, 7:30 p.m., Public Library. Jan. 6, O. R. Votaw, "Planets and Their Orbits."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Jan. 6, Sidney I. Scheuer, "Astronomy in Navigation."

Teaneck, N. J.: Bergen County Astronomical Society, 8:30 p.m., Observatory, 107 Cranford Pl. Jan. 13, Capt. C. V. Lee, "A Navigator Looks at the Stars."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Jan. 9, Dr. Stewart L. Sharpless, U. S. Naval Observatory, "Recent Findings of Studies on Galactic Structure."

MONTREAL MEETINGS

A series of popular public lectures on the theme, "An Introduction to Astronomy," is being given by the Montreal Centre of the Royal Astronomical Society of Canada, in the Macdonald physics building of McGill University at 8:15 p.m.

Remaining lectures in the series are: January 14, Charles M. Good, "Meteors and Comet Tales"; February 11, Henry F. Hall, "A Handful of Stars"; March 11, Francis P. Morgan, "The Milky Way"; April 8, Edwin E. Bridgen, "Beyond the Milky Way."

LOUISVILLE SOCIETY HAS 20th BIRTHDAY

The Louisville Astronomical Society celebrated its 20th birthday this fall. Organized in 1933 with a nucleus of university students, professors, and local amateurs, the society was incorporated in 1936. Its projects have included solar and meteor work, bird migration studies, variable star observing. From the beginning the society has co-operated with other natural science groups of the city wherever their activities were related. The education committee, under the chairmanship of Charles Strull, has prepared periodic astronomical articles for local newspapers.

One of the major projects for a number of years has been the grinding and polishing of a 20-inch telescope mirror. The mirror is now completed, and work is progressing on a mounting for it. An observatory with a 17-foot aluminum revolving dome is being constructed by Dr. Walter L. Moore, president of the society, on his farm, and this building will be lent by him to house the telescope for as long as the society wishes to keep it there.

Other projects for this year include the formation of a junior society for young people up to 18 years of age, and an evening free public lecture by a visiting astronomer.

MRS. MILDRED S. LANDAU
2436 Broadmeade Rd.
Louisville, Ky.

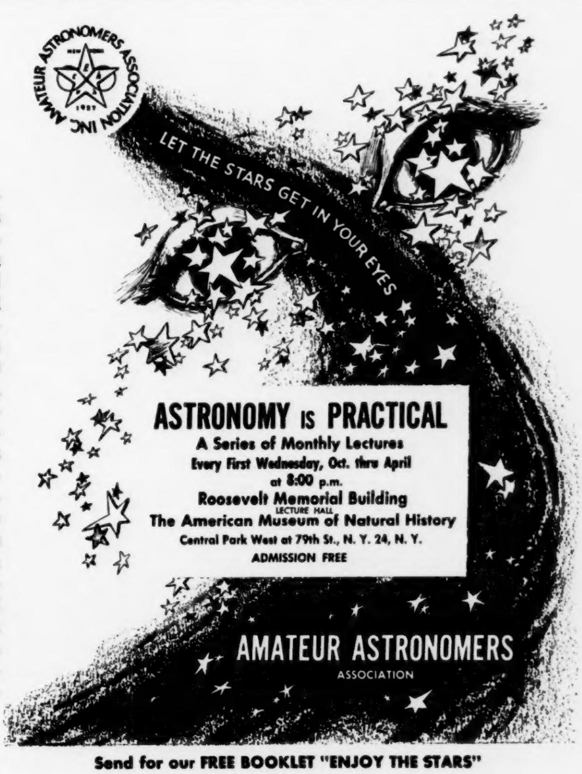
FLORIDA HIGH SCHOOL GROUP

Recently, a few of us at Ft. Lauderdale high school decided to form an amateur astronomy club for the benefit of students. The faculty supported us, and the student response was good. We have 15 members and expect many more. Telescopes in use include two 2-inch and two 3-inch refractors and a 6-inch reflector. We have recently embarked on the grinding of another 6-inch mirror.

JOSEF E. PARKO, JR.
1610 N. W. 4th Ave.
Ft. Lauderdale, Fla.

NEW YORK AMATEURS DISTRIBUTE PUBLICITY POSTER

The Amateur Astronomers Association this fall announced its regular lecture series with a starry poster, printed in blue, and a special letter about the activities of the society. This was sent to about 300 colleges, junior colleges, libraries, service organizations, scientific societies, and similar groups in the New York metropolitan area. The publicity and membership committee, under the chairmanship of Marion L. Louis, was responsible for the project, and the art and production work was carried on chiefly by Edgar Paulton and Helene Calamaras.



HERE AND THERE WITH AMATEURS (*continued*)

State	*City*	*Organization*	*Time*	*Meeting Place*	*Communicate With*
TEXAS	Dallas	†Texas A.S.	8:00, 4th Mon.	Various auditoriums	E. M. Brewer, 5218 Morningside, U-6-3894
	Ft. Worth	†*Ft. Worth A.S.	8:00, 4th Fri.	Texas Christian U.	A. W. Mount, 4326 Birchman
	Port Arthur	†*Port Arthur A.C.	7:30, 2nd Thu.	5228 Fifth St.	F. T. Newton, 5213 Fifth St., 2-4807
UTAH	Salt Lake City	†*A.S. of Utah	8:00, 2nd Fri.	City and County Bldg.	Junius J. Hayes, 1148 East 1 S.
VERMONT	Springfield	†Springfield T.M.s	6:00, 1st Sat.	Stellafane	John W. Lovely, 27 Pearl St., 535-W
VIRGINIA	Harrisonburg	Astral Society	7:30, 3rd Thu.	Vesper Heights Obs.	M. T. Brackbill, Eastern Mennonite College
	Norfolk	†*Norfolk A.S.	8:00, 2nd, 4th Thu.	Museum of Arts	A. Hustead, U.S. Weather Bureau, 21745
	Richmond	†*Richmond A.S.	8:00, 1st Tue.	Builders Exchange	J. S. Stith, 3125 Lamb Ave. (22)
WASHINGTON	Seattle	†*Seattle A.A.S.	8:00, 2nd Fri.	Rainier Field House	F. J. Ritscher, 1631 N. 53 St.
	Spokane	†*A.T.M.s of Spokane	8:00, Last Fri.	Private homes	Chet Brown, W. 1117-14th
	Tacoma	Tacoma A.A.	8:00, 1st Mon.	Coll. of Puget Sd.	Dorothy E. Nicholson, 2816 N. Union Ave
	Yakima	†*Yak. Am. Ast'mers	8:00, 2nd Mon.	Cha. of Comm. Bldg.	Edward J. Newman, 324 W. Yakima Ave.
WISCONSIN	Beloit	†Beloit A.S.	7:30, 2nd. 4th Wed.	YMCA Bldg.	K. E. Patterson, 318 Public Service Bldg.
	Madison	†Madison A.S.	8:00, 2nd Wed.	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
	Milwaukee	†*Milw. A.S.	8:00, 2nd Mon.	Public Museum	E. A. Halbach, 2971 S. 52 St., W. Allis

☆ ☆ SKY AND TEACHER ☆ ☆

Conducted by STANLEY P. WYATT, JR., *for the Teachers' Committee of the American Astronomical Society*

Block-and-Gap in the Introductory College Course

College calendars are normally so arranged that the teacher of astronomy can place his introductory course in one of two categories, according to the number of lectures permitted by the schedule. Two-semester courses (or their equivalent in quarters) provide ample time for lectures on all topics traditionally presented in elementary astronomy. If, however, the schedule calls for a one-semester course, it is clear that the subject matter must be tailored drastically in some fashion. It is with such short courses that this note deals.

The position of the course in a sequence leading to the bachelor's degree in astronomy cannot be neglected. We shall assume, however, that a long course is also offered to prospective majors, or that an intermediate-level class is provided to supplement the short course. It will be supposed, then, that the short course is primarily for those who are not majoring in any of the physical sciences.

One obvious solution is to survey briefly all aspects of astronomy — to present a dilute version of the long course. The argument for this plan is the desirability of introducing the student, however sketchily, to all phases of astronomy. This is commendable, provided important educational objectives do not suffer. The value of such a course must be measured by other yardsticks than comprehensive coverage.

What should the introductory course accomplish? Certainly, at the end of the term, the student is to have some familiarity with the principal astronomical phenomena; with the structure of the solar system, the Milky Way, and the extragalactic universe; with the nature of planets, comets, stars, nebulae, and the like. This descriptive function is important, and such a passive view of astronomy is adequately provided for in a survey course.

It is generally accepted, however, that in a course at college level the student should also become acquainted with the basic data on which the current descriptive picture is founded, the methods by which data are collected and evaluated, and the physical laws invoked or derived during the analysis. Time is surely needed to relate strictly astronomical matters to current work in allied fields. Finally, although it is now recognized that the old concept of *the* scientific method is not valid, it is of the greatest importance that an educated person have some appreciation of the accepted standards of intellectual probity in research. He should understand the roles played by observation, inspiration, and logical analysis of data. He should be shown examples of verification, modification, and disproof of hypotheses, and of the influence of the inevitable observational errors.

The objectives of the introductory course thus run far beyond a description of the current view of the astronomical universe, and should be at least partially realized in the abbreviated course.

At the University of Michigan we have been led to adopt the "block-and-gap" plan for our short course. We were convinced, at the outset, that a survey course would contribute very little to the student's education. Instead, we decided to make a judicious selection of topics, which were to be treated nearly as thoroughly as is customary in long courses. Between these blocks, we should necessarily leave the gaps — topics entirely omitted, or mentioned only cursorily.

The decision to adopt the block-and-gap system was easily taken; the actual selection of the blocks has required continuous experimentation, in which the enthusiasms (and prejudices) of the instructors have been important.

Our criteria for inclusion or rejection of subject matter have not been reduced to a formal statement, and each of the three instructors has made the selection which seemed to him most appropriate to the objectives of the course. Nevertheless, we have followed substantially the same procedures in our planning. A few broad topics have been selected. Some of these are treated in a consecutive series of lectures; others serve as recurring themes which lend continuity to the course. By proper choice, significant *descriptive* features are introduced, yet there is time for full discussion of problems which the instructor feels suited to illustrate the spirit, content, and methods of modern research.

Representative topics that we have adopted include the development and application of the laws of motion and gravitation, the measurement of astronomical distances, and the problem of evolution in astronomy.

Despite the necessity for omitting subjects traditionally taught in the first course (the writer, for example, does not lecture on time and spherical co-ordinate systems), it is our opinion that the block-and-gap technique is superior to the survey course, and that intensive treatment of properly selected subjects is far more stimulating to the good student than a necessarily superficial survey of the entire astronomical domain.

We have encountered one additional problem — choice of textbook. A text written for a brief survey course is unfitted for the block-and-gap course with its detailed discussion of a limited number of topics. It is also impossible that a book could be found to match the blocks chosen by any one instructor. In any case, it is essential that the text provide reference material for the student who is incited to browse in the gaps. We have therefore adopted one of the standard, full-length texts, from which we select assigned reading to accompany and supplement the lectures, and find this procedure entirely satisfactory.

FREEMAN D. MILLER
University of Michigan Observatory

BOOKS AND THE SKY

MAN AND HIS PHYSICAL UNIVERSE

An Integrated Course in Physical Science

Richard Wistar. John Wiley and Sons, Inc., New York, 1953. 488 pages. $4.75.

UNLIKE those college courses in general physical science which offer a drastically abridged review of astronomy, chemistry, geology, and physics, Richard Wistar has attempted to present a broad picture of several limited areas in science. Admittedly addressing the future citizen more than the future scientist, the author de-emphasizes the accumulation of special vocabulary, but rather hopes to enliven science by demonstrating how the scientist solves problems and how his results relate to the contemporary world.

The book is divided into six units: Photography, The Solar System and Beyond, The Story of the Earth, Forecasting the Weather, Electricity and Magnetism, and Atomic Structure. The section on photography seems to embrace more than its share of physics. One encounters cameras and f-values, and also quite properly some of the basic ideas of geometric and physical optics; but there is also included here a discussion of sound and the physics of music. Although intrinsically interesting, these latter topics are ill-placed and detract from the coherence of the unit. Summarily, the reader gains a good notion of how to make a picture and how to handle it in a darkroom, but there is no feeling that one has made an exciting integration of a number of important physical principles while learning the picture-making operation.

Although of necessity extremely brief, the part on astronomy is presented in fairly unified fashion. Errors of fact occur, however, with surprising frequency: the sun on June 21st, for example, assuredly does not rise 23½° north of the east point from wherever visible; the earth's albedo is certainly not equal to the moon's; nor does the axis of rotation of Uranus in general point nearly toward the sun. From the interpretive standpoint, few astronomers will agree with the author that the origin of the asteroids is a complete mystery, or that it is plausible that the moon came from the Pacific Ocean. It seems that a book titled as this one is should devote conspicuous attention to the outer limits of present-day astronomical research and offer a picture of the universe in the large; the galaxies, however, are disposed of in three brief paragraphs.

The structure of the earth is well described; and one here begins to sense the unity of physical science, for the discussion of earthquake waves and of the correlation of data on past glaciations with astronomical phenomena cuts nicely across chapter boundaries. A book that purports to be an integrated presentation ought to utilize many more such examples, perhaps even topics as abstruse as tidal evolution, to demonstrate with force how largely the boundaries between the four physical sciences are artificial.

Forecasting the weather is fun for anybody. It is also a well-chosen component of the book, for the discussion of our atmosphere frames a good account of the physics of gases and provides a geometric link between earlier subjects: earth and sky.

The unit on electricity and magnetism is most empirical in spirit. In a book that is in some respects promisingly different in approach, it is disheartening to find the usual textbook treatment of hard-rubber rods, cat's fur, and pith balls. Although telephone, radio, television, and automobile ignition systems are included, this section loses doubly in effectiveness. On the one hand, the general picture of electromagnetism does not emerge clearly; on the other hand, the practical topics are not dealt with in sufficient detail to train the reader as a handy man.

The final unit, atomic structure, is presented soundly and interestingly. Understanding would be enhanced, probably, if a few of the facts about radiation and fundamental particles were marshaled at the beginning, rather than falling out one by one as by-products of a historical review of experiments. Early in the book, the story of our developing ideas on planetary motion is admirable: it gives a sense of historical perspective. Here, the history gets a bit in the way and deflects one from getting at the facts.

In spite of mistakes in detail, **Man and His Physical Universe** is fairly lively reading for those whose interests happen to focus on two or three of the six units and who do not object to a somewhat

cursory presentation of the basic laws. But the reader who takes the subtitle at its face value and hopes to gain real insight into the unity of the physical sciences, the similarities in method, the principles useful in all, and the interlocking of subject matter, is probably due for disappointment.

STANLEY P. WYATT, JR.
University of Illinois Observatory

ASTROLOGY AND ALCHEMY: Two Fossil Sciences

Mark Graubard. Philosophical Library, New York, 1953. 382 pages. $5.00.

ON ENTERING Cambridge University in 1660, the youthful Isaac Newton, asked what he wished to study, replied, "Mathematics, because I wish to test judicial astrology." This anecdote has a strange and even unpleasant ring to us, living in an age when astrology has been wholly discredited among the educated.

Although it is a rather late example, the story reminds us that until the 17th century astronomy and astrology had been very intimately intertwined. Most of the great astronomers from Ptolemy down to that time wrote extensively on astrological topics, and their astronomical views were strongly colored by their astrological beliefs. Thus the long-range history of astronomy is intelligible only if some attention is paid to astrology, quite apart from the falsity of the latter, much the same way that the student of American history must read the books defending slavery if he is fully to appreciate the eve of our Civil War.

The historic relation between astronomy and astrology is clearly explained by Ptolemy in the opening words of his astrological treatise, the **Tetrabiblos,** which in medieval times was more widely known than his purely astronomical **Almagest.** Astronomy he defines as the science which predicts the motions and aspects of the sun, moon, and stars with respect to each other and to the earth; astrology investigates the effects that these aspects bring about. Ptolemy thus regarded astrology as the practical application of astronomy, and this viewpoint characterizes the following 14 centuries.

Perhaps the most generally interesting part of Graubard's history of astrology is his explanation of its decline and substantial disappearance. He puts much emphasis on ecclesiastical opposition. The belief that the stars controlled human destiny offended the theological doctrines of free will and the omnipotence of God. For example, papal bulls against astrology and magic were issued by Sixtus V in 1585 and Urban VIII in 1631.

Another factor was the growing formalism of astrology from the 14th century on, which ossified it into mere processes and banished the spirit of inquiry. This tendency invited attacks like that by Johann Essler of Mainz in 1508, who criticized the astrologers' neglect of astronomical advances, and their use of obsolete and erroneous planetary tables for their forecasts. The most thorough demolition of this sort was by Pierre Gassendi in 1655, whose influence was heightened by his great scientific reputation and by

his position as astronomer to the King of France.

Most important of all the causes of astrology's demise was the enormous growth of astronomy in the 17th century, spurred by improvements in observational techniques and by the acquisition of powerful new mathematical methods. With the rapid advance of astronomy came a new intellectual climate in which astrology could not be taken seriously.

The last third of Graubard's book deals in somewhat less systematic fashion with the analogous interrelation between alchemy and chemistry. It is instructive to see the vicissitudes of astrology and alchemy portrayed together. Just as astronomically useful observations were made for astrological purposes, so many early chemical discoveries were by-products of searches for the philosopher's stone and the elixir of youth. There is much analogy in the causes of decline of the two fossil sciences; and as the rise of Newtonian celestial mechanics banished astrology, the chemical revolution of Lavoisier drove out the last remnants of alchemy.

Graubard has taken evident pains to suit his book to the wider circle of those interested in the history of science and of ideas, rather than to the specialist alone.

J. A.

NEW BOOKS RECEIVED

Fun with Astronomy, *Mae and Ira Freeman*, 1953, *Random House*. 58 pages. $1.50.

Suitable for beginners of every age, this book provides a first introduction to astronomy. There are numerous simple experiments, such as measuring the diameter of the sun with a pinhole. About 100 photographs and diagrams illustrate the book.

Target: Earth, *Allan O. Kelly and Frank Dachille*, 1953, *Pensacola Engraving Co.*, Pensacola, Fla. 263 pages. $5.90.

The authors advance the theory that meteorite collisions have been a major factor in the recent history of the earth. A wide variety of geological formations is attributed to either direct impact or to flooding caused by the fall of huge meteorites into the oceans. The content of this rather unorthodox book is more geological than astronomical.

The Revolution in Physics, *Louis de Broglie*, 1953, *Noonday Press*. 310 pages. $4.50.

Writing for the layman, the author describes the developments in atomic physics during the present century. The main topics treated are the quantum theory of matter and radiation, and wave mechanics. One of the outstanding French physicists of today, Louis de Broglie received the Nobel prize in 1929 for his contributions to this subject. The translation is by Ralph W. Niemeyer.

A Guide to the Moon, *Patrick Moore*, 1953, *W. W. Norton and Co.* 255 pages. $3.95.

The secretary of the lunar section of the British Astronomical Association has written this handbook of the moon for amateur astronomers and lay readers. The emphasis is on lunar surface features, with brief descriptions of over 200 of the most important markings.

Dialogue on the Great World Systems, *Galileo Galilei*, 1953, *University of Chicago Press*. 506 pages. $12.50.

This is an English version of Galileo's famous classic, edited by Giorgio de Santillana and based on T. Salusbury's translation of 1661. There is an extended historical introduction, and numerous critical notes are provided.

Dialogue Concerning the Two Chief World Systems, *Galileo Galilei*, 1953, *University of California Press*. 496 pages. $10.00.

Stillman Drake has made a new translation into modern English, based on the definitive Italian edition of the Dialogue prepared under the direction of Antonio Favaro and published in Florence in 1897. There is a foreword by Albert Einstein.

Scientific American Reader, edited by the board of editors, Scientific American, 1953, *Simon and Schuster*. 626 pages. $6.00.

Fifty-seven articles that have appeared in *Scientific American* during the last five years are reprinted here, usually in slightly condensed form. The subjects range from galaxies to genes, and hydrogen bombs to chess-playing machines. The sections on astronomical themes are by Gamow on galaxies, Bok on the Milky Way, Gray on the Mount Palomar Observatory, Whipple on the origin of stars and planets, and Lovell on radio stars. An article by Marshak is on the energy of stars.

The Handbook of the British Astronomical Association 1954, edited by *J. G. Porter*, 1953, *British Astronomical Association*, 303 Bath Road, Hounslow West, Middlesex, England. 60 pages. 3s for members; 5s for non-members.

Every serious observer will find the BAA *Handbook* an invaluable aid. It contains ephemerides of the sun, moon, planets, and of the periodic comets expected to return in 1954. There are predictions of phenomena of Jupiter's satellites, and data for identifying the moons of Saturn. A very useful feature for the amateur is the set of finding charts for Uranus, Neptune, and Pluto.

This year's *Handbook* contains some new features. One is the list of predictions of occultations of stars by planets. Observers in the United States will be able to see occultations by Mars on April 2, 14, and June 6, and by Vesta on December 22, 1954. Another useful feature is the greatly expanded collection of data on the principal meteor showers.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

Notes on Basic Optics — V

F. Pupils and Aperture Stops

1. **Introduction.** The subject of pupils and aperture stops is seldom adequately covered in optical texts, yet its importance cannot be overestimated in understanding the function and design of optical systems.

The general situation is this. Every optical instrument consists of two distinct optical systems. The more familiar **image-forming** system defines essentially what the instrument does, and determines its magnification and image quality. The second is the **pupil-forming** system, which determines how well the instrument works, its illumination, eye relief, and the like. To give a workable instrument, the optical components must be chosen to satisfy the requirements of both systems simultaneously.

2. **The Exit Pupil.** By considering a simple telescope, the Keplerian system shown in Fig. 15, we can explain the function of the **exit pupil.** The telescope has an objective of focal length **f′** and an eyepiece of focal length **f″**, separated by the distance **f′ + f″**. From previous discussions, we know that a parallel beam incident on the objective from a point object on the optical axis at infinity will focus to a point **F** and then be transformed by the eyepiece into a parallel emergent beam, shown by the thin solid lines in Fig. 15.

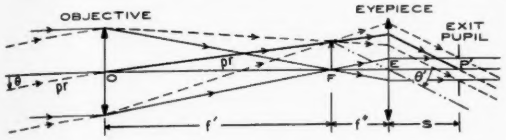


Fig. 15. The formation of the exit pupil.

Now consider a parallel beam incident from an off-axis point, entering the same system at an angle θ. As shown by the dashed lines, this bundle will also emerge from the eyepiece as a parallel beam, at an angle $\theta' = m\theta$, **m** being the magnification.

The two emergent beams intersect at **P′**, at a distance **S** from the eyepiece. If bundles of rays at other angles are constructed, they will all intersect the axial bundle at this same point. The exit pupil is the constricted area through which all these bundles of light pass, and is named for its analogy to the pupil of the eye.

Evidently, in using the telescope, the observer must place his eye at the exit pupil to see all the image. If his eye is displaced from the exit pupil some of the light bundles will be lost. The exit pupil is the knothole through which one must look to see the image and, as any small boy knows, to see effectively through a knothole one must put his eye as close to it as possible.

The exit pupil is readily located. In Fig. 15, note the central ray of the bundle, **pr**, which passes through the center of the objective and through the off-axis image point, and then emerges as the central ray of the emergent beam. This is commonly called the **principal ray** of the oblique bundle; it crosses the optical axis at the center of the pupil.

On drawing this ray as the heavy line in Fig. 15, we see that **P′** is the image of the point **O** formed by the eyepiece. Hence, its location is found by Equation 1 of our May installment, $1/d' - 1/d = 1/f$, where **d′** is **S**, **d** is $-(f' + f'')$, and $f = f''$. Therefore,

$$S = \frac{f''\,(f' + f'')}{f'}. \qquad (10)$$

Clearly, the whole exit pupil is nothing but the image, formed by the eyepiece, of the objective lens. The diameter of this image, following our discussion in September, is given by

$$\frac{\text{Exit pupil}}{\text{Objective}} = \frac{S}{f' + f''}, \qquad (11)$$

as the diameter of the objective lens is the object in this case. Substituting into this the value for **S** found in Equation 10 gives:

$$\frac{\text{Exit pupil}}{\text{Objective}} = \frac{f''}{f'} = \frac{1}{m}. \qquad (12)$$

3. **The Entrance Pupil.** The foregoing result is of general interest, because in this case the objective is the same as the **entrance pupil.** Equation 12 states that the ratio of the diameters of exit and entrance pupils is the reciprocal of the magnification. In other words, the greater the magnification, the smaller the exit pupil.

4. **Aperture Stops.** The objective lens of a system is not necessarily the entrance pupil. In fact, this is the case only for such very simple instruments as astronomical telescopes. It does not apply, for example, to a telescope with an erecting lens system, through which we draw the axial bundle of rays shown in Fig. 16A.

Now suppose the first erector, L_1, is too small to pass the entire bundle of

light, as shown by the dashed lines. Then only the bundle indicated by solid lines gets through to the exit pupil. The effect is as if we had reduced the diameter of the objective.

Next, what has happened to the light bundles from off-axis points? The largest bundle of light which can get through L_1 from the off-axis image point **P** is that shown in Fig. 16B. By the argument used above in Section 2, the exit pupil is now the image of L_1 instead of the objective. And if we draw the complete picture for two off-axis points (Fig. 16C), we see that the entrance pupil is the image of L_1 formed by the objective.

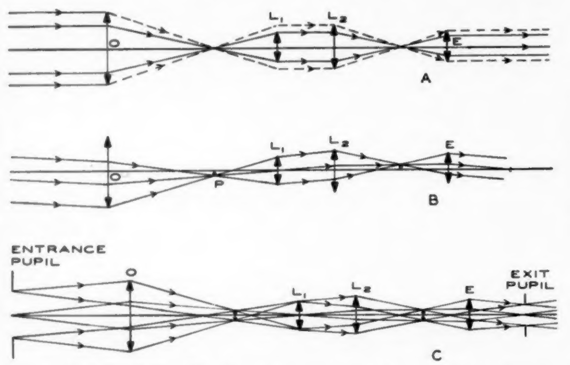


Fig. 16. Illustrating the principle of aperture stops in an erecting lens system, and the manner in which entrance pupil and exit pupil are related in the pupil-forming system.

We call L_1 the **aperture stop** of the system; it is the point where the axial bundle suffers its maximum restriction.

Fig. 17. Vignetting by a too-small objective.

The results found above may be summarized in more rigorous language as follows:

a. Every optical system has one point where the light bundle from an axial object point suffers its maximum restriction; this point is the aperture stop of the system.

b. The image of the aperture stop as seen from the object space is called the entrance pupil; its image as seen from the final image space is called the exit pupil.

c. The ratio of size of the entrance pupil to exit pupil is equal to the magnification of the instrument.

5. **Vignetting.** Still considering L_1 the aperture stop of the system, the objective itself needs to be sufficiently large for the full light beam for point **P** to enter and get through the system. When the objective is too small, part of the bundle will be cut off, as shown in Fig. 17, and vignetting results. The exit pupil for off-axis point **P** will show that only part of L_1 is filled with light, and will look as shown at the right in Fig. 17.

In all instruments of high magnification, the exit pupil is smaller than the pupil of the eye. But the vignetting that arises from this is seldom objectionable, since the eye is relatively insensitive to small differences in light intensity; in fact, vignetting up to about 50 per cent of the pupil area is not readily noticeable. Most optical instruments exhibit vignetting of about this magnitude.

6. **Location of Pupils.** Clearly, pupils and aperture stops are very important in optical design. Upon the proper location of the pupils depend such performance characteristics as size of field of view and illumination.

For a visual instrument, the exit pupil should be situated where the eye can be placed exactly in it, otherwise the field of view is reduced. The reason the Galilean telescope, commonly used in opera glasses, has such a small field of view is that the exit pupil lies **inside** the instrument. This is shown in Fig. 18, which represents a Galilean telescope consisting of an objective lens and a negative eyepiece lens, separated by the distance $f' + f''$. Thus, this arrangement, although

the simplest of all erecting telescopes, is not widely used.

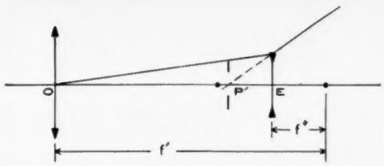


Fig. 18. Showing the position of the exit pupil in a Galilean telescope.

7. **Field Lenses.** In July, it was pointed out that in Equation 1 (where **d** and **d'** are the respective distances of image and object from a lens of focal length **f**) if **d** is zero, **d'** must also be zero. Thus, object and image coincide when both are at the lens itself. This is the basis of the fundamental principle that a lens may be placed directly in the focal plane of another lens without any first-order effect on the image formed by that lens. In other words, a **field lens** may be placed at any point in our system where an image is formed, whether by the objective or by other intermediate lenses, and have no primary effect on the image-forming system. But such a lens would not be in an image plane of the pupil-forming system, and it follows that this lens provides a very powerful means of controlling the locations of the pupils.

This can be made clear by two examples, of which the first is the ordinary telescope in Fig. 19A. Here there is no field lens. The exit pupil is the image of the objective lens, and the **eye relief**, or distance from eyepiece to exit pupil, is approximately equal to the eyepiece focal length.

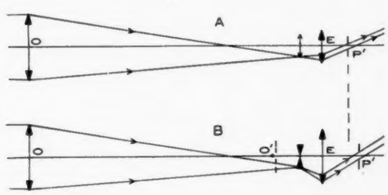


Fig. 19. How adding a field lens to a telescope gives greater eye relief.

Now put a negative lens in the focal plane, as in Fig. 19B. This lens forms a virtual image of the objective at **O'**, much closer to the eyepiece than the objective itself. Therefore, the eye lens forms the exit pupil farther behind the eyepiece, increasing eye relief. The eyepiece must now be made larger in diameter to accommodate the new exit pupil position, but this is a small price to pay when a large eye relief is desired, as in a gun sight or rifle scope.

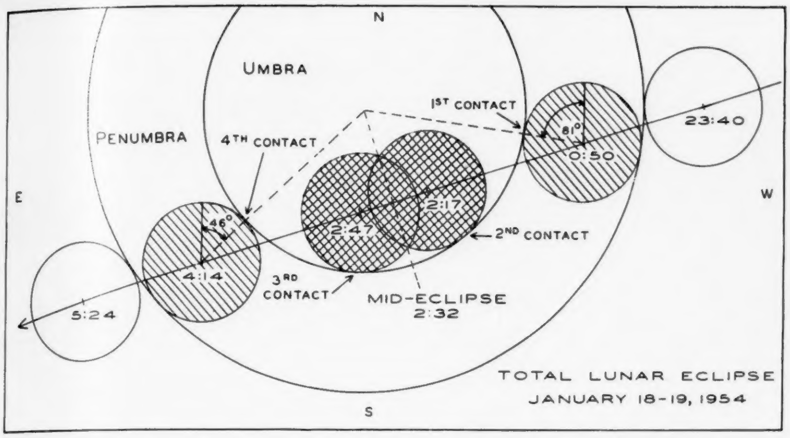
Our second example will be given in the March installment.

(To be continued)

GLEANINGS is always ready to receive reports and pictures of amateur instruments and devices, and is open for comment, contributions, and questions from its readers.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.



This diagram shows the passage of the moon through the southern part of the earth's shadow during this month's lunar eclipse. The times are taken from the "American Ephemeris," and the angles of contact are obtained from the graphical construction. Chart by Edward Oravec.

The Total Eclipse of the Moon on January 18 - 19

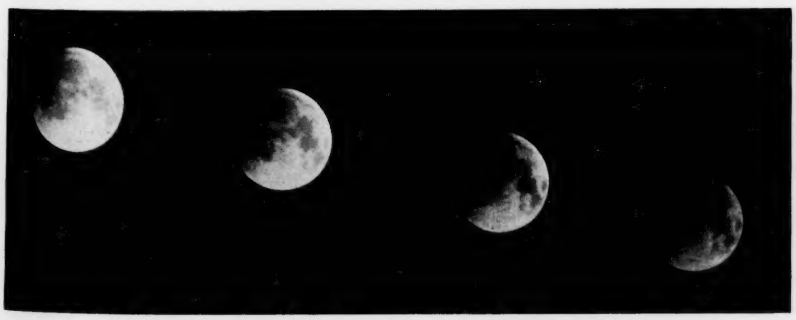
THE ONLY TOTAL eclipse of the moon this year may be observed throughout the United States and Canada on Monday night, January 18th. The entire eclipse will be visible during evening hours, though on the West Coast the phenomenon will have begun before moonrise. The total duration will be five hours 44.5 minutes, but totality will last only half an hour. Expressed in terms of the moon's diameter as a unit, the magnitude of the eclipse is 1.037, and the moon will be 240,300 miles distant, appearing 30′ 51″ in diameter. At that distance, the earth's umbra is about 80′ in diameter, but the moon will not enter deeply into the shadow. For some observers two 6th-magnitude stars will be occulted during the eclipse.

The penumbral phase of the eclipse will be inconspicuous, although some darkening may be noticed close to the border of the umbra. How dark the umbra will appear is unpredictable, for this will depend largely on conditions in the earth's atmosphere. Generally, the moon while in the umbra appears a copperish color, but its hue changes as the eclipse progresses. Useful observations that can be made during totality include noting the visibility of various lunar features, and watching for possible lunar meteor flares, for which confirmation by independent observers is desirable. Observations of times of beginning and ending of totality are also desirable, and these can be made to an accuracy of ½ minute or better with small telescopes.

The following schedule is adapted from the **American Ephemeris.** All times are p.m., January 18th, except for the last event in Eastern standard time, which occurs at 12:24 a.m., January 19th.

	EST	CST	MST	PST
Moon enters penumbra	6:40	5:40	4:40	3:40
Moon enters umbra	7:50	6:50	5:50	4:50
Total eclipse begins	9:17	8:17	7:17	6:17
Total eclipse ends	9:47	8:47	7:47	6:47
Moon leaves umbra	11:14	10:14	9:14	8:14
Moon leaves penumbra	12:24	11:24	10:24	9:24

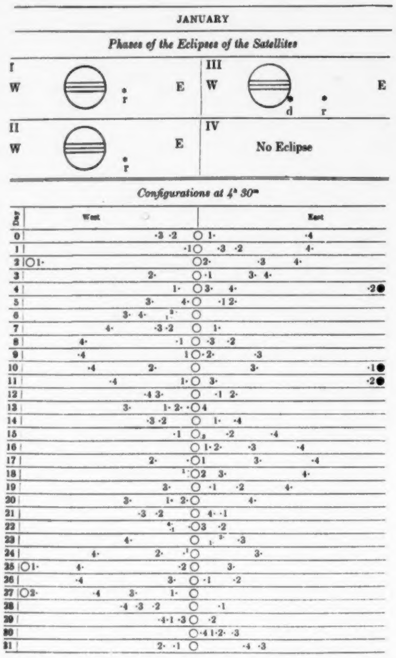
EDWARD ORAVEC



Early stages in the lunar eclipse of July 26, 1953, photographed by Leon E. Salanave, of the Morrison Planetarium. On Mt. Diablo, in California, at an elevation of 2,900 feet, exposures were made at five-minute intervals, from left to right, the first at 2:30 a.m. PST. The moon entered the umbra between the first and second images. Exposures were 1/125 second at f/11 on Ansco Isopan emulsion, without filter through a Wollensak 15-inch telephoto lens.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the American Ephemeris and Nautical Almanac.



OCCULTATION PREDICTIONS

January 9-10 **Kappa Piscium** 4.9, 23:43.5 +1-00.2, 5, Im: **A** 0:42.0 .. .. 348; **C** 0:29.0 −0.2 +2.8 4; **F** 0:01.9 +0.3 +4.0 355.

January 20-21 **Pi Leonis** 4.9, 9:57.8 +8-15.9, 16, Em: **I** 12:02.0 .. .. 230.

January 28-29 **Alpha Scorpii** 1.2, 16:26.6 −26-19.9, 24, Im: **H** 19:57.3 −1.5 −2.4 128.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

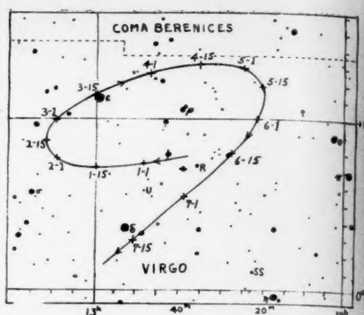
The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.6	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	+114°.0,	+50°.9
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



PATH OF CERES

The above chart shows the path of Ceres, Asteroid 1, from January 1 to July 15, 1954, to the same scale as that for Pallas published last month. Ceres will brighten from magnitude 7.6 in January to 7.2 at opposition on April 3rd, and then fade to 8.1 in July. The chart is a tracing by Edward Oravec from the Skalnate Pleso atlas, to show stars brighter than magnitude 7.75. Other objects, such as the numerous Coma-Virgo galaxies, are omitted. The AAVSO "a" field chart of R Virginis, a long-period variable, shows comparison stars for estimating the brightness of Ceres.

ZURICH SUNSPOT NUMBERS

The Zurich daily sunspot numbers given below were furnished by the National Bureau of Standards. The American numbers are suspended pending the reorganization of the Solar Division of the American Association of Variable Star Observers. Meanwhile, it is hoped that these Zurich numbers will give amateur solar observers a standard with which to compare their observations. The American and Zurich sunspot numbers last appeared in **Sky and Telescope** for September, 1953.

July 1, 0; 2, 7; 3-5, 0; 6, 7; 7, 7; 8, 0; 9, 9; 10, 20; 11, 22; 12, 16; 13, 23; 14, 24; 15, 40; 16, 19; 17, 16; 18, 21; 19, 11; 20, 8; 21, 14; 22-31, 0.

August 1, 0; 2, 7; 3, 12; 4, 12; 5, 11; 6, 10; 7, 16; 8, 10; 9, 29; 10, 48; 11, 73; 12, 77; 13, 73; 14, 65; 15, 62; 16, 54; 17, 47; 18, 31; 19, 26; 20, 24; 21, 17; 22, 10; 23, 8; 24-31, 0.

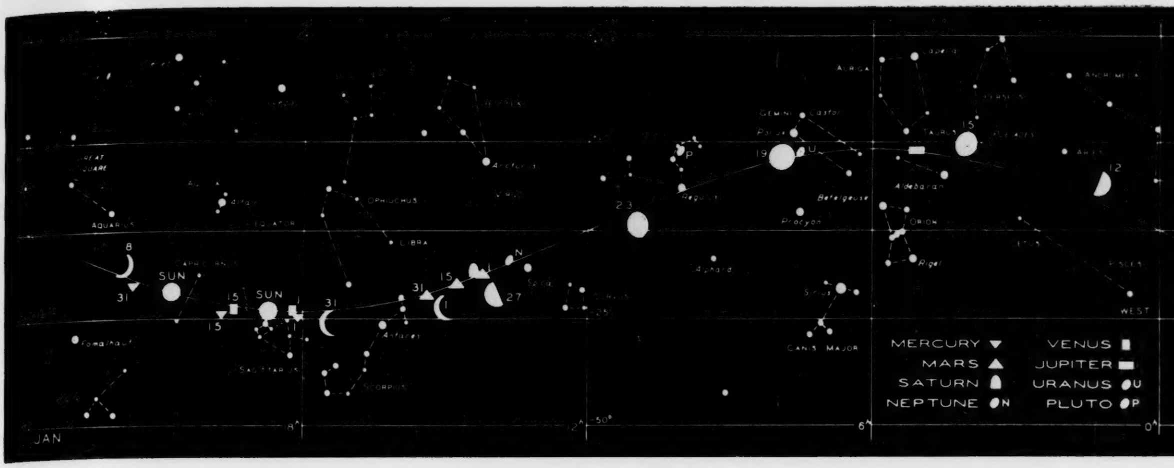
September 1, 0; 2, 0; 3, 7; 4, 0; 5, 7; 6, 7; 7, 9; 8, 24; 9, 23; 10, 27; 11, 32; 12, 29; 13, 18; 14, 30; 15, 43; 16, 42; 17, 38; 18, 38; 19, 34; 20, 17; 21, 25; 22, 16; 23, 9; 24, 15; 25, 14; 26, 14; 27, 0; 28, 9; 29, 7; 30, 9.

HARRY L. BONDY
43-58 Smart St.
Flushing 55, N. Y.

MOON PHASES AND DISTANCE

New moon	January 5,	2:21
First quarter	January 12,	0:22
Full moon	January 19,	2:37
Last quarter	January 27,	3:28
New moon	February 3,	15:55

	January		Distance	Diameter
Perigee	10,	10^h	229,800 mi.	32′ 19″
Apogee	25,	12^h	251,500 mi.	29′ 32″
	February			
Perigee	6,	6^h	226,600 mi.	32′ 46″



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Sun. An annular eclipse of the sun takes place on January 5th, visible only in the antarctic regions. The path of annularity comes close to the South Pole; except for this fact, the eclipse will be of little interest.

Moon. As described on page 99, there will be an eclipse of the moon on January 18-19.

Mercury passes superior conjunction with the sun on January 14th, entering the evening sky, and the planet is invisible all month.

Venus reaches superior conjunction on the 30th, and cannot be viewed until March.

Mars rises five hours before the sun and is on the meridian in the southern sky by sunrise. The ruddy planet is moving eastward through Libra, passing 1° 17′ south of Saturn on January 2nd. Its stellar magnitude is +1.4 in mid-month; the planet steadily increases its brightness until opposition in June.

Jupiter is the brilliant yellowish object high on the meridian in the evening. Shining at magnitude —2.2 in mid-January, the planet is in retrograde motion in eastern Taurus. On the 15th, the equatorial diameter will be 46″; Jupiter with its satellites is an excellent object for the small telescope.

Saturn comes to western quadrature with the sun on January 29th, rising shortly after midnight. The planet appears at magnitude +0.8 on the 15th, moving slowly eastward in Libra. The rings present an inclination of 18°.7 on that date, with a longest diameter of 37″.6.

Uranus is in opposition to the sun on January 11th and may be viewed with the slightest optical aid throughout the night. This distant planet is located about 5½° east of Delta Geminorum; it is moving westward, in retrograde motion.

Neptune, visible after midnight with the assistance of binoculars, comes to western quadrature on January 16th. An interesting conjunction with the 5th-magnitude star 82 Virginis occurs about the 28th of the month. Neptune will be about 30″ south of the star for several nights, as it begins retrograde motion on the 28th.

E. O.

DEEP-SKY WONDERS

IN SOME RESPECTS it is unfortunate that the most interesting parts of the Milky Way lie in the hemisphere of the sky opposite from the most densely populated areas of our earth. The observer in the United States who would delve into southern declinations must watch for the few rare evenings when the atmosphere is not hazy or moisture laden, when the air is actually free of all trace of cirrus—unnoticed at the zenith, but a distinct handicap near the horizon. Then he may dip into the tempting riches of Vela, Pyxis, and Puppis. This month, on a moonless night just after the passage of a cold front, try the clusters below Sirius, and especially the following, which are little known to amateurs.

NGC 2539, at 8^h $8^m.4$, —12° 40′ (1950), is a bright, loose cluster 21 minutes of arc in diameter, containing over 150 stars between the 10th and the 13th magnitudes. Both Smyth and Webb mention it, and because 19 Puppis lies in the same field it is easy to locate.

NGC 2627, at 8^h $35^m.5$, —29° 46′, is smaller, eight minutes in diameter, with perhaps half a hundred stars from magnitudes 11 to 13. It lies south-preceding Zeta Pyxidis and almost in the same field. On a perfect night, under powers of 50 to 100, it is a magnificent starburst which, were it farther north, would be a favorite object of stargazers.

Much more difficult is NGC 2784, 9^h $10^m.1$, —23° 58′, a nebula of magnitude 11.8, three by one minutes in size. It is the merest blot of nebulosity. Probably a spiral, it is about as close to the Milky Way as we usually ever see external galaxies; in fact, it probably suffers from some obscuration. I will be happy to hear from any reader who has observed this object, especially from someone in low latitudes.

WALTER SCOTT HOUSTON

COMET ABELL

A new comet has been found at the Palomar Observatory by George O. Abell, on a photograph taken with the 48-inch Schmidt camera on October 15th. A preliminary orbit computation by Dr. Leland E. Cunningham, of the University of California, shows that the comet will pass perihelion in July, 1954. At that time the new comet, now a faint 15th-magnitude object in the constellation Camelopardalis, may become bright enough to be seen in small telescopes. Dr. Cunningham's orbit, however, is based on observations extending over only five days, so that accurate predictions for next summer are not yet possible.

MINIMA OF ALGOL

The period of Algol's light variations is subject to small changes that are only partly understood, and so cannot yet be foretold. Therefore the best way to predict the times of coming minima is by carrying forward a recent accurately observed epoch of minimum, with the aid of an average value of the period. The predictions listed below are based upon a minimum observed photoelectrically at the Cracow Observatory, Poland, by S. Piotrowski, at Julian Day 2433928.4944, and the average period of 2.86731 days. Last year's ephemeris of Algol was computed from older data and, if extended, gives times about 17 minutes earlier than these. The predictions given here are geocentric and not heliocentric; they are the times that would be seen by a terrestrial observer, and so may be compared directly with the observed minima.

January 3, 4:12; 6, 1:00; 8, 21:49; 11, 18:39; 14, 15:28; 17, 12:17; 20, 9:06; 23, 5:55; 26, 2:44; 28, 23:34; 31, 20:23. February 3, 17:12.

VARIABLE STAR MAXIMA

January 1, V Bootis, 142539, 7.9; 1, RT Sagittarii, 201**139**, 7.9; 2, T Herculis, 180531, 8.0; 5, T Cassiopeiae, 001755, 7.8; 8, RR Sagittarii, 194**929**, 6.6; 10, X Centauri, 114**441**, 7.8; 17, R Cygni, 193449, 7.3; 21, R Leporis, 045**514**, 6.7; 31, R Virginis, 123307, 6.9. February 6, RS Scorpii, 164**844**, 6.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

JANUARY METEORS

During the first week of January, one of the better annual meteor showers may be seen. The Quadrantids, with predicted rates of 30 to 40 per hour, after midnight, come to maximum on the 3rd of the month. The radiant is in northern Bootes, at R. A. 230°, Dec. +52°. The meteors are of medium speed. The moon will be near new and will not interfere with observations.

E. O.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sunday, 2:00 to 5:30 p.m. Admission free. Spitz projector.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Public Library Building, Charleston, W. Va.

SCHEDULE: Saturday, 11:15 a.m. Special showings on request. Admission free. Spitz projector. Director, Louise L. Morlang.

CHEROKEE, IA.: *Sanford Museum Planetarium.* Sanford Museum, 117 E. Willow St., Cherokee, Ia.

SCHEDULE: Monday, 8 p.m. (except August). Admission free. Spitz projector. Director, W. D. Frankforter.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:00 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.

SCHEDULE: Saturday, 3:00 p.m.; Sunday, 3:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday, Thursday, and Friday at 8:30 p.m.; Saturday and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., 42-1858.

SCHEDULE: Sunday, 2:45, 3:30, 4:15. Spitz projector. Supervising lecturer, James C. Foster.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

SCHEDULE: Saturday, 2 and 3 p.m.; Sunday, 2:15 and 3:15 p.m.; Wednesday, 8 p.m. Spitz projector. In charge, Ray Stein.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. General manager, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.: Sundays and holidays, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.

SCHEDULE: Saturday, Sunday, and Wednesday, 4:00 p.m.; Tuesday, Thursday, and Friday, 8:00 p.m.; Saturday show for children only, 10:30 a.m. Spitz projector. Director, Stanley H. Shirk.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

SCHEDULE: Wednesday at 3:30 p.m.; Saturday at 10:30 a.m., 2:30 and 3:30 p.m.; Sunday, 2 to 5 p.m. Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

SCHEDULE: Daily (except Monday and Tuesday) at 3:30, 7:30, and 9 p.m.; also at 2 p.m. on weekends and holidays. Academy projector. Manager, George W. Bunton.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

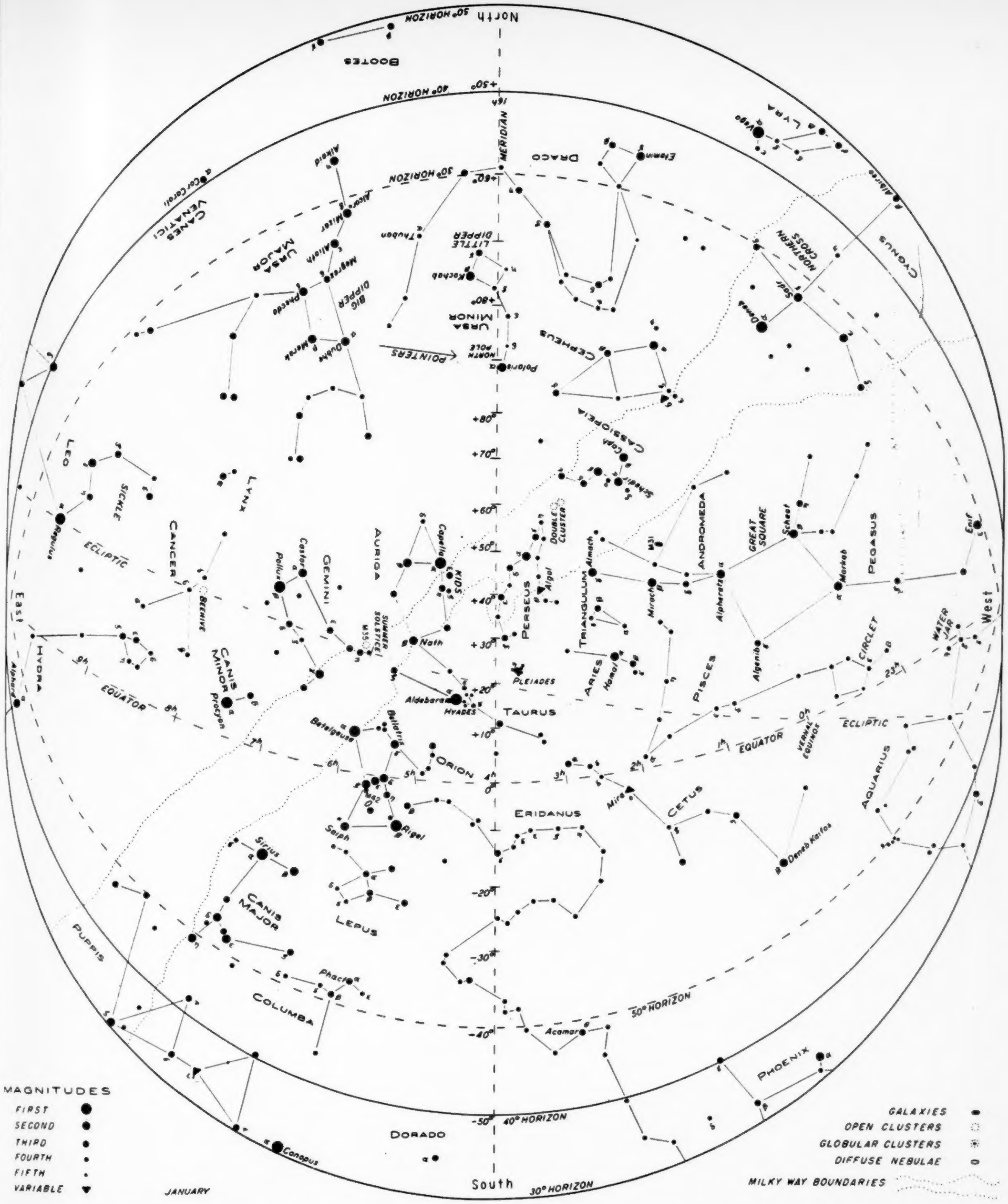
SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Sunday 4:00 p.m. Admission free. Spitz projector. Director, Ernest T. Luhde.

ST. PETERSBURG: *Rice Planetarium.* 4700 Lakeview Ave., St. Petersburg, Fla.

SCHEDULE: Daily, 10:30 a.m., 2:30 and 8 p.m.; Sunday, 2:30 p.m. Spitz projector. Director, Laban Lacy Rice.



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of January, respectively.

STARS FOR JANUARY

DURING January evenings, the most striking of the constellations is Orion, the Hunter. High in the southeastern sky, it is easily recognized by the compact row of three 2nd-magnitude stars forming Orion's belt, flanked north and south by Betelgeuse and Rigel, respectively.

Once Orion is located, some neighboring constellations are readily picked out. Thus the stars of the belt point downward to Sirius, the brightest star in the sky, situated in Canis Major, the Great Dog. Following the line of Orion's belt upward leads to the orange 1st-magnitude star Aldebaran, in Taurus, the Bull.

Even at first glance, the contrast in color between the bluish-white Rigel and the reddish Betelgeuse is apparent. The latter is a much cooler star than Rigel; it is the brightest example of the red supergiants, a vast tenuous orb of gas so large that the earth's orbit could easily be hidden inside it. Like other red supergiants, Betelgeuse varies in brightness in semiregular fashion. In some years it appears as bright as Rigel, and in other winters as faint as Aldebaran. These variations are attributable to a slow pulsation of the star, as it expands and contracts in a six-year cycle.

Rigel is the most distant of the 1st-magnitude stars, save for Deneb and for Canopus in the southern sky. This fact, coupled with Rigel's great apparent brilliance, places it among the intrinsically most luminous stars visible to the eye.

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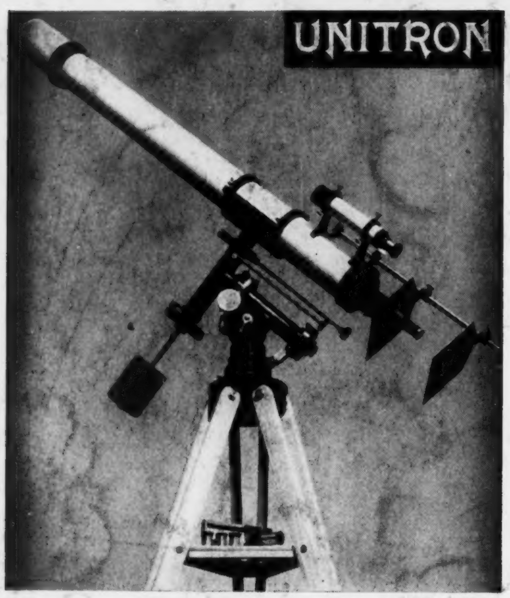

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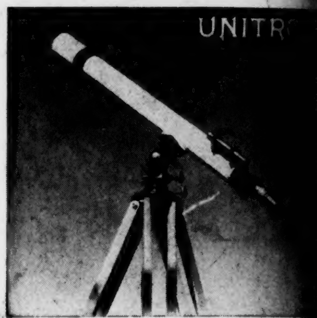

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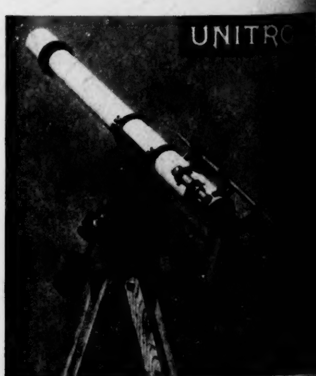

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